Vol. LIII No. 3

THE BOTANICAL GAZETTE

March 1912

Editor: JOHN M. COULTER

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Current Literature

The University of Chicago Press
CHICAGO, ILLINOIS

Agents
THE CAMBRIDGE UNIVERSITY PRESS, *London and Edinburgh*
WILLIAM WESLEY & SON, *London*
TH. STAUFFER, *Leipzig*
THE MARUZEN-KABUSHIKI-KAISHA, *Tokyo, Osaka, Kyoto*

The Botanical Gazette

A Monthly Journal Embracing all Departments of Botanical Science

Edited by JOHN M. COULTER, with the assistance of other members of the botanical staff of the University of Chicago.

Issued March 15, 1912

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The following agents have been appointed and are authorized to quote the prices indicated:

For the British Empire: The Cambridge University Press, Fetter Lane, London, E.C., and William Wesley & Son, 28 Essex Street, Strand, London. Yearly subscriptions, including postage, £1 12*s.* 6*d.* each; single copies, including postage, 3*s.* 6*d.* each.

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For Japan and Korea: The Maruzen-Kabushiki-Kaisha, 11 to 16 Nihonbashi Tori Sanchome, Tokyo, Japan. Yearly subscriptions, including postage, Yen 15.75 each; single copies, including postage, Yen 1.75 each.

Claims for missing numbers should be made within the month following the regular month of publication. The publishers expect to supply missing numbers free only when they have been lost in transit.

Business correspondence should be addressed to The University of Chicago Press, Chicago, Ill.

Communications for the editor should be addressed to him at The University of Chicago, Chicago, Ill.

Contributors are requested to write scientific and proper names with particular care, to use the metric system of weights and measures, and in citations to follow the form shown in the pages of the BOTANICAL GAZETTE.

Papers in excess of thirty-two printed pages are not accepted unless the author is willing to pay the cost of the additional pages, in which case the number of pages in the volume is correspondingly increased.

Illustrations are furnished without cost to author only when suitable originals are supplied. A copy of the suggestions made in the January number, 1907, will be sent on application. It is advisable to confer with the editors as to illustrations required in any article to be offered.

Separates, if desired, must be ordered in advance of publication. Twenty-five separates of original articles without covers will be supplied gratis. A table showing approximate cost of additional separates is printed on an order blank which accompanies the proof; a copy will be sent on request.

Entered August 21, 1896, at the Post-office at Chicago, as second-class matter, under Act of Congress March 3, 1879.

VOLUME LIII NUMBER 3

THE

BOTANICAL GAZETTE

MARCH 1912

THE MORPHOLOGY OF LEITNERIA FLORIDANA

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY 154

WANDA M. PFEIFFER

(WITH PLATES XVIII–XX)

Former investigators examining *Leitneria* have come to such different conclusions as to its proper place among Archichlamydeae that it seemed worth while to look into its morphology in the hope that some interesting situations might be uncovered.

Material and methods

The material used was obtained from plants in the Missouri Botanical Garden of St. Louis. The first material was collected during the winter and spring of 1908, and was killed in a dilute solution of chromo-acetic acid by Miss LAURA D. WATKINS, who sent it to the laboratory in 70 per cent alcohol. I spent the last week in March 1908 in St. Louis. Pollen of *Leitneria* was beginning to be shed on March 28, which gave me an opportunity to pollinate some of the flowers of pistillate plants which stood a considerable distance from any staminate ones. During this week I made frequent collections in the hope of obtaining fertilization stages.

In the next year, living material was sent to me about twice a week from early in January until late in July. I again spent the week when pollen was ripe in St. Louis, and pollinated practically all the pistillate catkins in the garden except those which grew on seven twigs which were covered with paper sacks in order to

prevent pollination. This last precaution was taken because the large amount of fruit produced in previous seasons on pistillate plants remote from staminate plants made the occurrence of parthenogenesis seem possible. The twigs bearing the catkins pollinated were carefully labeled, both as to the location in which they grew and the time of pollination. Again frequent collections (two every day) were made for about five days after pollination.

The first catkin collected had sections cut off each side to allow the more easy penetration of the killing fluid, and were then killed *in toto*. Owing to the difficulty in orienting the material, and to the fact that the hairs on the bracts made the cutting of smooth sections practically impossible, in all the later material the pistils and the stamens were picked out of the catkins before killing.

The young ovaries were killed in Flemming's weaker solution, while some of the later stages in the development of the ovule and of the seed were killed in 1 per cent chromo-acetic acid. The material was imbedded in paraffin and sections cut from 2–10 μ in thickness. The stains used were the combination of safranin and gentian violet, with the addition of gold orange in some cases. The solution of gold orange in clove oil to be used after clearing in clove oil was found to be more satisfactory than the alcoholic solution.

Historical

The work done on *Leitneria* previous to 1894 was largely taxonomic, and has been cited by TRELEASE (1) in a paper of that year describing the plants of *Leitneria* found growing in the lowlands of southeastern Missouri. He considered the habit and distribution of the plant and its various taxonomic features, and besides this the structure of the wood, calling attention to its extremely low specific gravity, and concluding with a discussion of the position *Leitneria* had held in various schemes of classification. The portion of the paper with which we are most concerned has to do with the catkins. Of these it is said:

> On mature plants the upper axillary buds are generally flower buds, and develop in the autumn into oblong, erect, subsessile, hairy catkins, about half an inch long, surrounded at base by bud scales, which pass into the very acute scales of the inflorescence. The trees are dioecious. . . . . The flowers expand

before the leaves, early in March. . . . . The staminate catkins then become from one to two inches long, generally curved outward, and their scales spread just enough to expose the stamens and allow the very abundant and powdery yellow pollen to escape. The soft parenchyma of the axis of inflorescence becomes torn in various directions as the catkins elongate, so that when they have reached their full development it is loosely fissured throughout. . . . . The staminate flowers, so far as I have examined them, are glabrous and quite destitute of a perianth or involucre of any description, and consist simply of a whorl of about ten short filaments, a little dilated at base and surmounted by slightly versatile but nearly erect, extrorse, two-celled anthers, dehiscing longitudinally. The pollen grains are nearly globose, smooth, slightly 3-4-grooved with underlying thickening of the intine, and fall from the dehiscent anther very readily, and there is no doubt that the species is wind-pollinated.

The pistillate catkin possesses the same loose lacunose structure as the staminate, though the axis is far less torn. When fully developed they are rarely over half an inch long. . . . . Unlike the staminate flowers, the pistillate, which are limited to the upper axils, are very short-stalked or with a rudimentary disk, and possess a rudimentary involucre or perianth of a few small, glandular-fringed scales, the largest two of which stand nearly laterally, while the remainder are dispersed along the side next the axis of the catkin. Only one carpel is present. The ovary is shortly ovoid, finely pubescent, one-celled, and contains a single ascending parietal ovule with the micropyle directed upward. The green or slightly reddish style is attached a little at one side, and in anthesis curves outwards and becomes grooved on the stigmatic side, or somewhat flattened, with the stigmatic surface undulated, possessing the general characters of wind-pollinated stigmas. The placenta and stigmatic groove are turned away from the axis and face the bract, a very unusual position for the suture in a monocarpellary flower, and one which appears to indicate that the flower is in reality reduced from a former state in which there were two carpels radially arranged with reference to the bract, or perhaps a larger number. . . . .

The fruit is an erect drupe. . . . . Its surface is coarsely rugose reticulated over the firm fibrovascular bundles of the pericarp. Near the top it is marked by an oblique scar left by the caducous style, and it contains a single large seed with a straight embryo and rather thin layer of albumen.

The microsporangium

The microsporangium passes the winter in the mother cell stage. In the youngest stamen examined there were four microsporangia, each with a considerable amount of sporogenous tissue in the mother cell stage. The mother cells numbered as high as five across the sporangium, while beyond these there sometimes were

as many as six layers of cells, three of which might become tapetal, while the others formed the sporangium wall. On the opposite side of the sporangium the tapetum was usually only one layer of cells in thickness, these evidently derived from the sporogenous mass (fig. 1). In longitudinal section of the sporangium, the spore mother cells were seen to lie in plates somewhat separated from each other (fig. 1).

By the middle of February the separation of the plates of sporogenous cells from each other was marked (fig. 2). By this time the tapetal cells, especially those on the inner side of the sporangium, were beginning to break down and appeared as much distorted cells, while the tabular cells which formed the inner layers of the sporangium wall became very much flattened and took stain more readily (fig. 2).

In the mature anther the cell walls had all disappeared except the well-developed endothecium inside of the epidermis. There are two pollen sacs which dehisce longitudinally with no definite stomium.

The megasporangium

The earliest stage observed showed the megasporangium as a rather massive protuberance inward from the side wall of the ovary cavity. On January 21 some of the ovules showed the beginning of the inner integument. By February 16 the outer integument had begun its development, and the growth of the ovule had been such that a median longitudinal line through the ovule had been shifted from practically perpendicular to the longitudinal axis of the carpel to a position nearly parallel with it. The growth of the integuments from this time on was somewhat irregular, sometimes the outer and sometimes the inner growing more rapidly. There was in either case apparently an excessive development of integuments, so that when the embryo sac was ready for fertilization they not only closed over the nucellus, but lay in folds above it (fig. 3). At this stage the innermost layer of cells of the inner integument had much greater cytoplasmic contents than the other cells.

In the nucellus, which was relatively massive, there was evidently one archesporial cell picked out. The earliest stage examined

showed a single sporogenous cell and two parietal cells (fig. 4), which evidently arose by the periclinal division of the primary parietal cell. The further division of the parietal cells continued steadily, so that within four weeks there were often more than 10 parietal cells lying between the sporogenous cell and the epidermis (fig. 5). Very often a periclinal division of the epidermal cells of the nucellus occurred (fig. 5). The time when the mother cell went into synapsis varied greatly, some of the ovules showing this condition as early as February 16 (fig. 5), while others showed the mother cell in a presynaptic condition as late as March 22. However, at this later date the majority of mother cells were in synapsis.

Although the division of the megaspore mother cell was not observed, it evidently gave rise to a linear tetrad of megaspores. Above the micropylar end of the young embryo sac there were often three deeply stained masses (fig. 6), which had the same appearance as recognized abortive megaspores in other forms.

As the embryo sac developed, the further periclinal and anticlinal divisions of the parietal tissue continued, so that when the sac was ready for fertilization there were often as many as 30 layers of cells lying above it. Very often the tip of the nucellus developed into a somewhat slender beak, which took the form of the more or less twisted integuments (fig. 3).

The female gametophyte

After the formation of the row of megaspores, the innermost or functional spore immediately began division. In material collected on March 21 and killed on March 25 the embryo sacs were practically all in the four-celled stage. The two-celled stage figured (fig. 6) was of material killed on March 25 of the preceding year. It would seem that the embryo sac remained in the four-celled stage for some time, since material killed on March 30, April 3, and April 5 showed practically all the sacs in this condition. An ovule killed in the afternoon of April 5 showed the simultaneous division of these four nuclei to form the light nuclei of the completed sac.

In the mature embryo sac the egg has the usual organization, with the vacuole toward the micropylar end, but the synergids

are almost entirely without vacuoles and the position of their nuclei is irregular (fig. 7). The antipodals are usually evanescent.

The male gametophyte

The stages of pollen tube formation and of fertilization were not observed, and this fact, under ordinary circumstances, might have led to the belief that the form was parthenogenetic. This makes peculiarly fortunate the precaution which was taken early in the season, of preventing pollination in some of the pistillate catkins. As has been described previously, this was accomplished by covering with paper sacks seven of the twigs bearing pistillate flowers before pollen began to fly. Although each of these twigs bore about five catkins and each catkin contained several pistils, there was not a single case of seed formation observed. One may safely infer that parthenogenesis is not of usual occurrence in this form.

The endosperm

The fusion of the polar nuclei and male cell was not observed, but must have occurred about April 15. Material killed on this date showed the eight-nucleate sac, but material killed on April 16 showed the large endosperm nucleus. It may be that division of this nucleus did not take place immediately, since all the material examined within the five days following this shows it undivided. Material killed on April 22 showed two free endosperm nuclei. After this, the simultaneous free nuclear division goes on rapidly, so that by the time the division of the fertilized egg occurred there were sometimes as many as 35 of these parietally placed nuclei to be seen in a single section (fig. 8*a*). The increase in size of the sac, due to growth of the ovule itself, and the breaking down of tissues about the sac and especially below it was very great. By May 10 the endosperm was seen as a very thin layer of cytoplasm about the embryo sac, which extended over three-quarters of the length of the ovule, which itself measured as much as 6 mm. About this time the formation of walls in the endosperm began, and this was followed by a centripetal growth of tissue so regular as to give the endosperm the appearance of being made up of plates of cells. These cells were large and contained unusually large nuclei. This

was especially true of the tissue at the chalazal end, which was a very loose tissue and contained large, irregular nuclei, which were possibly produced by the fusion of several nuclei.

The embryo

After free nuclear division had continued for some time in the endosperm, the division of the fertilized egg occurred. The first two-celled embryos seen were in material which was killed April 30. It was a matter of indifference in which plane the first division wall should lie, so that in some cases (fig. 8) the first wall was parallel to the longitudinal axis of the embryo sac, while in others the position was the horizontal one almost universal in the embryos of angiosperms. In whichever plane the first division occurred, other divisions followed rapidly in all planes, so that there was in no case a slender suspensor formed. In fact, in the young stages the embryo was somewhat pear-shaped, with the massive suspensor only slightly narrower than the body of the embryo (fig. 9*a*).

The growth of the embryo, and indeed of the whole fruit, was very rapid. Figs. 8*a*, 9*a*, and 10*a*, which were drawn to the same scale, show the increase in size of the embryo itself within the first five weeks. Fig. 9 shows the detail of a few cells of the endosperm and the outermost layer of cells of the embryo at the micropylar end of the embryo sac. It will be noticed that at this stage, when the embryo consisted of a relatively large number of cells, there was as yet no evidence of the appearance of cotyledons (fig. 9*a*), the embryo proper still appearing as a globular mass of cells. Shortly after this, however, the cotyledons began to appear as protuberances from the distal end of the embryo, and within a few weeks there was the well-organized embryo as shown in the diagram (fig. 10*a*.) Cell detail of the suspensor region of the embryo is shown in fig. 10, where it will be noticed in comparison with fig. 9, which shows some of the outer cells of this region, that there had been but slight increase in the size of the cells of this region. Fig. 11 shows, under slightly less magnification than fig. 10, the detail of cell structure of the root end of the embryo and the lower portion of the suspensor. At this stage, examination even under low magnification showed a clearly defined periblem (fig. 10*a*). Under

higher magnification (fig. 11) it was seen that plerome, dermatogen, and calyptrogen all arose from a common group of meristematic cells, and that these regions were not yet clearly defined. The periblem was more easily picked out by the larger size of its cells and their relatively less cytoplasmic contents. At this stage of the embryo it was evident that the cotyledons were to be net-veined, as might be expected. The rapid growth of the embryo continued until at maturity it approached 1 dm. in length. Fig. 12 is a diagram showing the size of the seed and the position of the embryo within it.

The seed

The tremendous rate of growth of the seed made it seem worth while to look somewhat into the method of food supply. In the development of the ovule there was a very early differentiation of tissue in the chalaza. On March 25, when the embryo sac was in the two-nucleate stage, there was seen extending across the chalaza, from the base of the inner integument, a rather narrow layer of cells, which, having more densely granular cytoplasmic content, took a deeper stain than the other cells of the region (fig. 14). Immediately outside of this layer of cells, which for convenience we will speak of as the nutritive layer, there was a layer of cells elongated transversely to the axis of the ovule, which was continuous with the vascular bundle of the funiculus (figs. 13 and 14).

The cells of the nutritive layer divided repeatedly, so that by the time the development of the embryo sac was completed there was quite a mass of them showing very clearly, even under low magnification, on account of their deeper stain. At about the time that the embryo sac was ready for fertilization, the appearance of these cells changed, and under low magnification they could now be picked out by their lighter stain. Higher magnification showed them to have almost no granular cytoplasmic content (fig. 15). Very shortly after this it was seen that there was being deposited in the cells some reserve material, probably tannin, which did not stain with the iron-haemotoxylin combination. This deposition began at the periphery of the cell and proceeded toward the

interior (fig. 16). Finally the cells were so packed with material that it was impossible to distinguish even the nuclei.

As the endosperm nuclei began division, growth in all parts of the ovule became very rapid, and this rapid rate of growth continued up to the maturity of the seed. While this was going on the reserve material in the nutritive layer began to disappear gradually, and as it went the cells of the perisperm immediately above it, which had increased considerably in size, were seen to contain numbers of starch grains (fig. 17).

Coincident with the differentiation of the nutritive cells is the development of the conducting cells immediately below it. Fig. 14 shows the elongation of the cells of this region, and their general relation to the nutritive layer when it could first be distinguished in the condition of the ovule seen in fig. 13. Somewhat later the thickening of the walls of these elongated cells to form tracheary tissue was seen (fig. 18). At the time when the nutritive layer is most conspicuous on account of its large amount of reserve material, a section tangential to the disk of nutritive cells immediately below it shows the conducting tissue in the form of a radiating plate of tracheary tissue (fig. 19), so that very often in the longitudinal section through the ovule there were found transverse and oblique sections of the vessels rather than longitudinal as seen in fig. 17.

At maturity the seed consisted of an embryo with two thin, very broad cotyledons. About the embryo was a considerable mass of large-celled endosperm tissue whose cells were packed with starch. The perisperm was a relatively thin layer of loose tissue. These regions, as well as the relative thickness of the seed coats, are seen in the diagram (fig. 12). Immediately outside of the epidermal layer of the nucellus there is a thick layer of cutin, which entirely covers the micropylar end of the seed. So closely abutting this layer of cutin that it is impossible to tell whether it was laid down by these epidermal cells of the nucellus or by the innermost layer of cells of the integument, lies the inner integument. It seems probable that the cells of both these closely abutting layers may have contributed to the layer of cutin lying between them. These cells of the innermost layer are the only cells of the inner integuments which are at all conspicuous. In these cells the walls

had become irregularly thickened, so as to have a pitted appearance in surface view. The outer layers of cells of this integument have all collapsed, as is best seen in fig. 20. In the outer integument the development had been different, for while here too the outermost layer of cells had unthickened walls, all the remaining cells had the pitted wall (fig. 20), giving in section a rather conspicuous seed coat. It is interesting to note that the outer integument, which in the early stages of the development of the ovule seemed excessively developed (fig. 7), here extended but a very little distance beyond the tip of the nucellus (fig. 12).

Discussion

In handling a form about whose position taxonomically there have been so many differences of opinion, it seems worth while to attempt to summarize the forms which are similar to *Leitneria* in various particulars, in order to see whether it could be placed on the basis of its morphology.

In the case of the stamen, there is no particular in which it differs strikingly from the stamen of other catkin-bearing forms. The microsporangia pass the winter in the spore mother cell stage, as do those of *Salix glaucophylla* (**2**), *Alnus glutinosa* (**3**), *Corylus americana* (**3**), and *Ulmus americana* (**4**). That such a character should be given little weight taxonomically, however, becomes evident when one looks at such a group as Hamamelidaceae. SHOEMAKER (**5**) in his study of this family reports all variations in the stage in which the stamens of the different genera of spring-flowering forms pass the winter. Of *Liquidambar Styraciflua* he says "stamens are only small protuberances which do not show any archesporium"; of *Fothergilla Gardeni*, "they pass the winter in the pollen mother cell stage"; while of *Hamamelis arborea* and *Corylopsis pauciflora*, the stamens "pass the winter containing nearly mature pollen grains with two free nuclei."

The developing megasporangium containing a single archesporial cell differs from most of the Amentiferae yet reported upon. However, this condition is found in *Betula alba* (**6**) and in *Alnus glutinosa* (**6**), and is usual in various species of *Salix* (**2**), and therefore the character of a multicellular archesporium could hardly be

considered a group character. Again, the extent of tissue development in the nucellar region is so variable a character that one finds reports of deeply placed embryo sacs, such as are found in *Leitneria*, reported in *Casuarina* (**7, 8**), in *Triticum* (**9**), in *Cuphaea* (**10**), and in other entirely unrelated forms.

Another character which *Leitneria* has in common with the majority of Archichlamydeae is the initiation of the development of the embryo sac by a megaspore rather than by a megaspore mother cell, so that while a tetrad of spores is formed, a single megaspore functions. In the embryo sac that develops from this megaspore the synergids are characterized by being full of cytoplasm, rather than by having the large, distinct vacuole, as often found in the antipodal end of the cell. This, while a character not often reported for the synergids of forms even where the synergids are relatively small, is of course not a character which would hold any weight taxonomically. The ephemeral antipodals are found in many forms, as in the Salicaceae and Cupuliferae.

After fertilization, the behavior of the endosperm nucleus and of the fertilized egg is in no way extraordinary; while extreme in some cases, as in the great development of free nuclei of the endosperm before the division of the fertilized egg occurs, still there is no character of first importance which would indicate relationship with one family or another. Thus the more or less extensive development of free endosperm nuclei before the segmentation of the egg is a character shared by *Piper* (**11**) and *Asclepias* (**12**). The very regular centripetal growth of endosperm tissue after walls appear is extreme, and is rarely found so well developed in angiospermous seeds. The most striking character of the embryo itself is the massive suspensor. But this character, too, is shared by most of those forms, such a *Peperomia pellucida* (**13**), in which the first division of the fertilized egg may be longitudinal rather than transverse. It is of interest to find here again a form in which there is no fixed sequence of cell divisions in the development of the embryo, such as have long been emphasized in such forms as *Capsella*.

One might go on indefinitely pointing out some particular in which *Leitneria* resembles one or the other of the Archichlamydeae,

without in the end establishing any definite relationship with a specific group. The thing which does impress one, however, in looking over the work that has been done on Amentiferae, is the general resemblance to gymnosperms. Thus in working through the life history of such a form as *Leitneria*, one is constantly reminded of gymnosperms by one detail of structure or another. Thus, in the wood of *Leitneria*, one finds tracheae which show in every case an incomplete disappearance of the cross walls of the rather short cells of which they are composed, so that in section one sees clearly at the periphery of the vessel the remains of these walls. More striking than this incomplete disappearance of septa across the tracheae is the predominance of tracheids with bordered pits.

As might be expected, it is in the study of the reproductive parts that one finds the most striking reminders of gymnosperm structure. Thus it is a relatively easy matter to imagine the derivation of a catkin from the compound strobilus found among gymnosperms. In either case the structure is made up of a series of bracts in whose axil stand sporophylls. In both gymnosperms and the Amentiferae the characteristic number of megasporophylls per bract is two, but it is in no way surprising to find this number occasionally reduced to one, as in *Leitneria*, while in the larger number of miscrosporophylls per bract we have a parallel among Gnetales, the only group of gymnosperms which has the compound staminate strobilus.

Within the carpel the ovule also has several characters in which it resembles that of gymnosperms. Thus we find that it is a relatively massive structure, with a large development of nucellar tissue above the megaspore, so that the female gametophyte when it develops is deeply placed in tissue.

Summary

The microsporangium passes the winter in the spore mother cell stage.

In the solitary ovule, the archesporial cell divides early; on January 21 there were two parietal cells above the single archesporial cell.

There is a large development of parietal tissue in the ovule, as many as thirty layers of cells lying above the embryo sac at its maturity.

Practically all megaspore mother cells were in synapsis on March 22.

A linear tetrad of megaspores was evidently formed.

By April 7 practically all embryo sacs showed the eight-nucleate female gametophyte.

After fertilization the endosperm nucleus divides repeatedly, giving rise to a large number of free nuclei before the division of the fertilized egg occurs.

After wall formation in the endosperm begins, there is an extremely regular centripetal growth of tissue.

The first division of the fertilized egg may be longitudinal or transverse; in either case a massive suspensor is formed.

The young embryo is a pear-shaped mass which is composed of hundreds of cells before the cotyledons appear.

In the root tip of the embryo, calyptrogen, dermatogen, and plerome arise from a common meristematic group of cells.

The growth of the seed is very rapid, and at maturity it contains a large, flat, dicotyledonous embryo, a thin layer of endosperm tissue, and a few layers of perisperm cells.

The seed coat is formed mostly from the outer integument, the inner integument contributing only its innermost layer of cells.

The morphology of *Leitneria* is not such as would make it possible to place it definitely in any of the families of the Archichlamydeae, but, in common with other Amentiferae, it suggests the possibility of the derivation of Amentiferae from such forms as one finds among the gymnosperms which have compound strobili.

The author is indebted to Professors JOHN M. COULTER and CHARLES J. CHAMBERLAIN, under whose direction this work was done, and to the staff of the Missouri Botanical Garden of St. Louis for aid in collecting material.

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EXPLANATION OF PLATES XVIII–XX

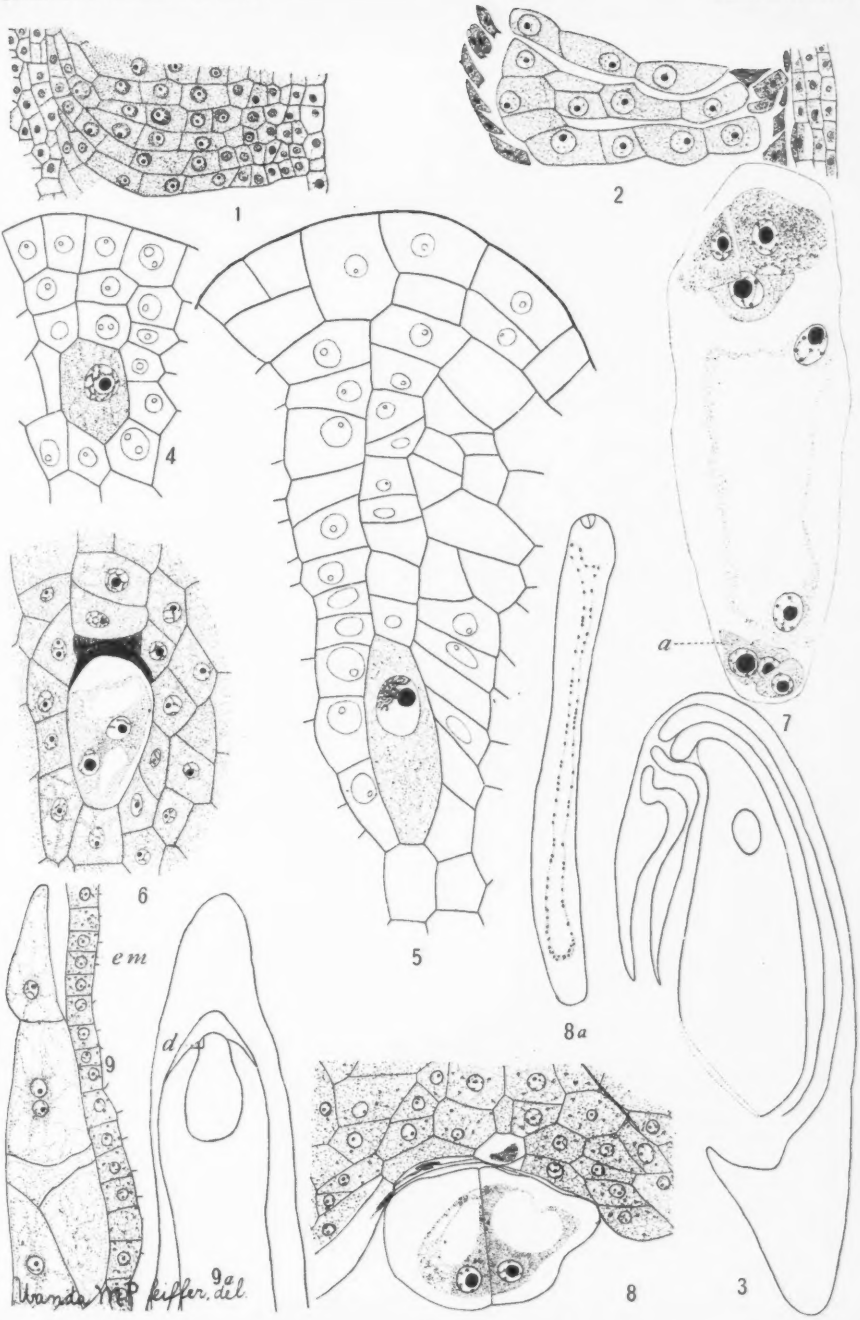
All figures were made with an Abbé camera lucida. A Zeiss microscope was used with ocular 4 and objectives 2/3 and 2 mm.

Abbreviations: *a*, antipodals; *en*, endosperm; *em*, embryo; *n*, nutritive layer; *c*, conducting tissue; *o*, outer integument; *i*, inner integument.

FIG. 1.—Portion of a longitudinal section of a stamen in winter condition; ×600.

FIG. 2.—Similar portion of a stamen Feb. 16, showing the separation of the plates of spore mother cells and the breaking down of tapetal cells; ×600.

FIG. 3.—A diagram through the ovule when the embryo sac is mature, showing the position of the embryo sac and the great development of integuments; ×600.



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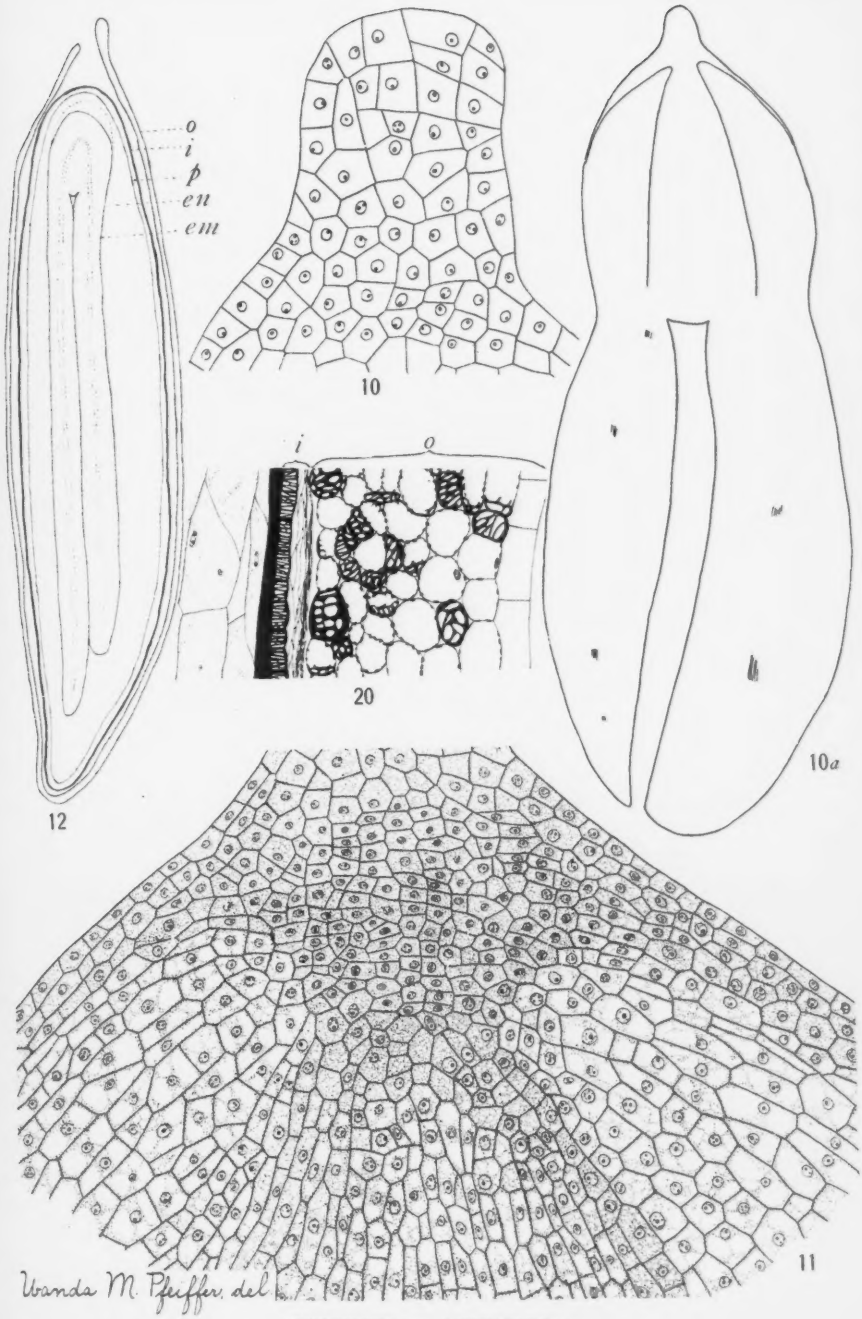

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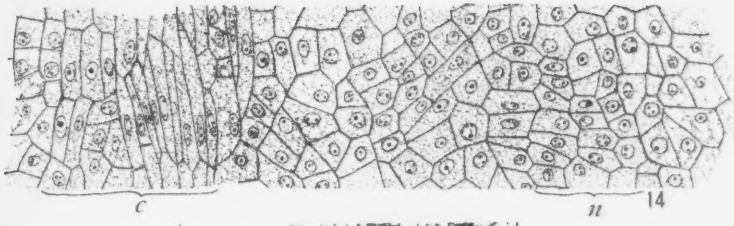

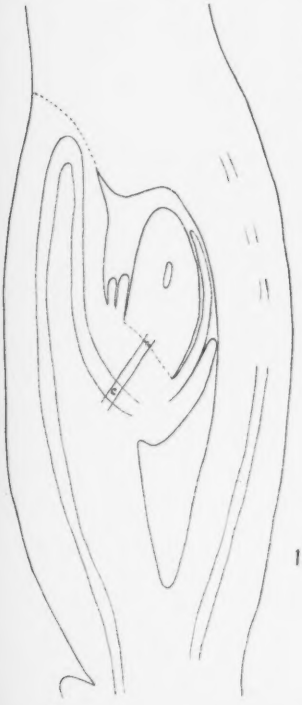

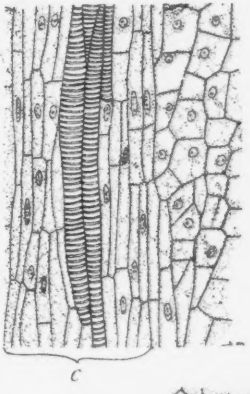

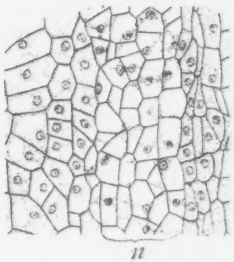

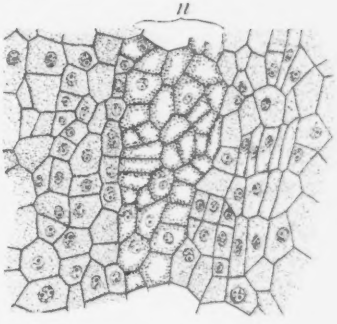

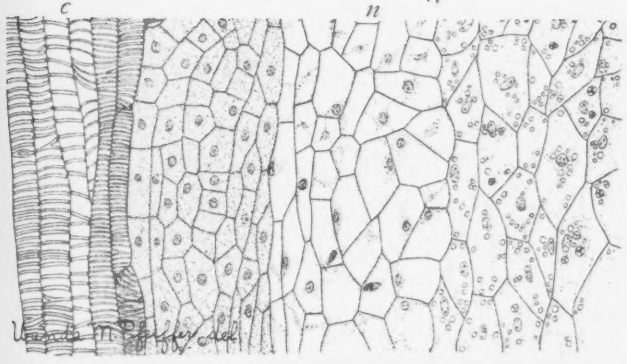

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FIG. 4.—Portion of nucellus of ovule on Jan. 21, showing the single sporogenous cell and two parietal cells; ×550.

FIG. 5.—Portion of nucellus four weeks later, showing the periclinal division of some of the epidermal cells, the further development of parietal tissue, and the megaspore mother cell in synapsis; ×600.

FIG. 6.—Two-nucleate female gametophyte, with three abortive megaspores immediately above it; ×600.

FIG. 7.—The eight-nucleate embryo sac; ×600.

FIG. 8.—Two-celled embryo, showing the longitudinal division of the fertilized egg; ×600.

FIG. 8*a*.—Diagram showing the position of the two-celled embryo seen in fig. 8, and the extensive endosperm in the free nuclear condition; ×55.

FIG. 9.—Detail of a portion of the outer layer of cells of the embryo seen at *d* in fig. 9*a*, and the contiguous endosperm cell; ×600.

FIG. 9*a*.—Diagram showing position of the young embryo and the absence of a slender suspensor; ×55.

FIG. 10.—Detail of the suspensor region of the embryo seen in diagram in fig. 10*a*; ×600.

FIG. 10*a*.—Diagram of an older embryo, showing the developing cotyledons; ×55.

FIG. 11.—Detail of the cell structure of root end of the embryo and the lower portion of the embryo; ×450.

FIG. 12.—Diagram of a mature seed, showing the position of the embryo and the extent of the endosperm, perisperm, and seed coats; ×12.5.

FIG. 13.—Diagram showing a young ovule with the position of the nutritive layer shown in a broken line, and the region shown in detail in fig. 14 marked out; ×55.

FIG. 14.—Detail of cell structure of region of chalaza marked out in fig. 13, showing the elongating cells whose further development is seen in figs. 17 and 18, and the appearance of the nutritive layer (*n*) when it can first be distinguished; ×600.

FIG. 15.—Detail of nutritive tissue somewhat later, when the cells seem almost free of cytoplasm; ×600.

FIG. 16.—Detail of nutritive tissue after deposition of reserve material has begun; ×600.

FIG. 17.—Detail of region seen in fig. 14, after the cells of the nutritive layer again lost their reserve material; endosperm cells with starch; ×600.

FIG. 18.—The region *c* of fig. 14 when the nutritive tissue is in the condition seen in fig. 15.

FIG. 19.—Diagram showing radiating plates of conductive tissue in the chalaza.

FIG. 20.—Detail of seed coat and outer portion of perisperm.

THE INFLUENCE OF THE SEED UPON THE SIZE OF THE FRUIT IN STAPHYLEA. I

J. ARTHUR HARRIS

(WITH FOUR FIGURES)

A previous paper in this journal[1] reviewed the chief literature bearing on the theory that the size attained by a fruit is to some extent determined by a stimulus exerted by the developing seed. The purpose of the present contribution is to consider the data from two series comprising 3277 fruits of *Staphylea*, collected in a manner to permit of carrying the analysis somewhat farther than was possible with the *Cercis* material.

I. Nature of the characters considered

The fruit of *Staphylea trifolia* is familiar to botanists as a three-lobed, three-celled, membranaceous, inflated pod, producing from 0 to 4 bony seeds in each locule. Unfortunately it is hardly of the form one would select especially for an investigation of the size. Its considerable irregularity renders measurement difficult, and its lightness makes weighing tedious. Its use in the present study is in part a consequence of the ease with which the necessary data could be obtained in connection with other studies of fertility and fecundity in the species, and in part a result of special advantages which will be apparent to the reader later.

In a fruit whose shape and texture precludes any very accurate determination of size, the thing to be done is to take measurements on a scale coarse enough that minor irregularities will not be of much account. Having done this, we should not attach great importance to the exact values of the calculated constants, but look at them as merely rough approximations. Consistent results from a number of individual series will strengthen our confidence in the soundness of our conclusions, but if the relationships are of a very slight intensity, we should expect, for reasons well known

[1] HARRIS, J. ARTHUR, On the relationship between the length of the pod and fertility and fecundity in *Cercis*. BOT. GAZ. **50**:117–127. 1910.

to the statistician, different series of material to yield somewhat discordant results.

For a first study it seemed undesirable, considering the irregularity of the pod, to take measurements in fine units, and readings were made of the length of the fruit to the nearest 0.5 cm. The number of ovules formed and the number of seeds developing can be fairly easily counted.

II. Material

Shrubs of *Staphylea* growing in the "North American Tract" of the Missouri Botanical Garden furnished the material for this investigation. These are in part the individuals upon which a study of selective elimination[2] was based in the spring of 1908, and the numbers of the plants are comparable.

In 1906 the fruiting of *Staphylea* seemed to be quite normal, and a series of about 100 fruits each were obtained from 20 shrubs. In 1907 there was a severe frost which inhibited entirely the fruiting of some of the trees; altogether only 1218 fruits were obtained, as compared with 2059 in 1906. In 1906 the fruits were taken from shrubs 11–20, but in 1907 it was necessary to take shrubs 11–41 to get 16 individual series of material of suitable size. Only three-loculed fruits were used.

In the reduction of the data the biometric methods, now familiar in a general way to most working biologists, were used.[3] For the benefit of biologists who are inclined to be wary of mathematical symbols, I may explain that no difficulties of that kind will be met if a few simple ideas are kept in mind. For convenience and terseness of expression, the characters investigated are designated by letters: o=number of ovules per locule[4]; s=number of seeds per locule[4]; f=number of ovules failing to develop to mature seeds per locule[4]; p=position of fruit on the inflorescence; n=number of fruits per inflorescence; $r_{ls} > r_{lo}$ is to be read "the correlation (r being the symbol for correlation) between the length of the pod

[2] HARRIS, J. ARTHUR, On the selective elimination occurring during the development of the fruit of *Staphylea*. Biometrika 7: 452–504. 1910.

[3] Unless especially noted, SHEPPARD'S correction was not used for the second moment.

[4] Or occasionally total number per fruit, when this is indicated by the context.

and the number of seeds developing is greater than the correlation between the length of the fruit and the number of ovules formed."

III. Analysis of data

We first examine our data to ascertain whether there is a measurable degree of interdependence between the length of fruit and the number of ovules formed, and between the length of fruit and the number of seeds developing per locule.

A. DISCUSSION OF DATA FROM INDIVIDUAL SHRUBS

Perhaps the criticism, in these days, most generally directed at biometric work is that in the massing of large numbers of individuals into correlation tables, biological relationships which otherwise might be recognized are obscured. "The fundamental requisite for the validity of biometric constants is the homogeneity of the material upon which they are based," we are told. There is more than one word to be said on this point, but certainly it is always desirable to consider data in as minutely analyzed form as can be done without incurring too great dangers incident to the probable errors of random sampling.

From PEARSON'S investigations[5] we know that plant individuals of the same race are somewhat differentiated among themselves with respect to the characters of the organs which they produce. In short, they are *individual* really as well as nominally. The combination of series of fruits taken from a small number of plants might influence to some extent the correlation constants describing the relationship between the fertility of the fruit and its length. To free our results as far as possible from any such source of error, I first consider the relationship of the number of ovules formed (o) and the number of seeds developing (s) to the length of the fruit (l) in each of the 20 shrubs of the 1906 series, and each of the 16 of the 1907 collection. In the large series it is also of interest to compare the correlation for the length of fruit and number of ovules failing to develop into mature seeds (f). For these relationships 92 correlation tables are necessary. While experience has shown that it is desirable that all tables of data should be published, it really

[5] PEARSON, K., and others. Phil. Trans. Roy. Soc. London A **197**: 285–379. 1901.

seems unreasonable to ask a publisher to print such a series. I retain my original tables, which are available to anyone desiring to consult them, and have deposited a duplicate set in the Library of the Missouri Botanical Garden.

TABLE I

CORRELATIONS FOR FRUIT LENGTH AND FERTILITY; 1906 SERIES

Number of shrub	r_{lo}, Length and ovules per locule	r/E_r	r_{ls}, Length and seeds per locule	r/E_r	r_{lf}, Length and ovules failing per locule	r/E_r
11	−.246±.035	7.02	.376±.032	11.75	−.399±.031	12.87
12	.201±.034	5.91	.347±.031	11.18	−.093±.035	2.66
13	.300±.035	8.56	.537±.027	19.87	−.258±.036	7.17
14	.103±.039	2.63	.328±.035	9.36	−.185±.038	4.87
15	.124±.037	3.34	.247±.035	7.05	−.042±.038	1.08
16	.180±.038	4.74	.347±.034	10.19	−.083±.039	2.13
17	.198±.037	5.35	.311±.035	8.87	−.050±.038	1.30
18	.014±.039	.36	.343±.034	10.07	−.264±.036	7.30
19	.068±.039	1.75	.320±.035	9.14	−.129±.038	3.32
20	.117±.037	3.15	.533±.027	19.75	−.325±.033	9.84
21	.026±.039	.67	.439±.031	14.15	−.382±.034	11.22
22	.333±.034	9.78	.343±.034	10.10	−.166±.037	4.48
23	.096±.039	2.44	.315±.035	8.98	−.153±.039	3.91
24	.244±.037	6.58	.418±.032	13.05	−.178±.038	4.67
25	.175±.038	4.59	.475±.030	15.83	−.300±.035	8.56
26	.167±.038	4.40	.456±.031	14.70	−.225±.037	6.08
27	.247±.037	6.68	.421±.032	13.15	−.117±.038	3.67
28	.082±.038	2.14	.364±.033	11.02	−.227±.036	6.31
29	.093±.039	2.37	.415±.032	12.95	−.270±.036	7.50
30	.043±.039	1.08	.402±.033	12.18	−.297±.036	8.25

The physical constants (means, standard deviations, and coefficients of variation) for the characters dealt with need not detain us here. The correlations for the 1906 series are given in table I, and for the 1907 series in table II.[6] Assuming, as is generally done, that a correlation coefficient of 2.5 times its probable error may be regarded significant, we may examine the results for the 1906 series.

In one case r_{lo} is significantly negative; the remaining 19 constants are all positive, and 12 are greater than $2.5\ E_r$. There can be no doubt of the significantly positive correlation between length and number of seeds per locule. Comparing r_{lo} and r_{ls} by means of

[6] In calculating the probable errors for these individuals, N was taken as the number of locules, not as the actual number of fruits; perhaps the latter course would have been better. There is always some question as to what should be done in cases of this kind. See PEARSON, Phil. Trans. Roy. Soc. A **197**:295, footnote; HARRIS, Biometrika **7**:308–309. 1910.

TABLE II

CORRELATIONS FOR FRUIT LENGTH AND FERTILITY; 1907 SERIES

Number of shrub	r_{lo}, Length and ovules per locule	r/E_r	r_{ls}, Length and seeds per locule	r/E_r
11	.261 ± .057	4.56	.296 ± .056	5.26
17	.383 ± .046	8.41	.148 ± .052	2.84
19	−.005 ± .047	.11	.271 ± .043	6.28
24	.101 ± .038	2.64	.291 ± .035	8.24
29	.154 ± .046	3.36	.424 ± .039	10.96
31	.132 ± .038	3.53	.421 ± .031	13.42
32	.135 ± .043	3.14	.305 ± .040	7.67
33	.152 ± .039	3.88	.397 ± .034	11.75
34	.168 ± .043	3.95	.490 ± .033	14.72
35	−.022 ± .046	.48	.439 ± .037	11.94
36	.376 ± .043	8.79	.467 ± .039	11.98
37	.021 ± .040	.53	.419 ± .033	12.78
38	.040 ± .040	.99	.398 ± .034	11.84
39	.209 ± .057	3.65	.413 ± .050	8.32
40	−.255 ± .036	7.05	.334 ± .034	9.71
41	.132 ± .049	2.70	.303 ± .045	6.69

table III, we find in every case $r_{ls} > r_{lo}$, and that in 17 cases of the 20 it is significantly greater in comparison with its probable error. All the correlations for l and f are negative, and 17 out of the 20 may be safely regarded as significantly negative.

TABLE III

$r_{ls} - r_{lo}$ FOR 1906

Number of shrub	Difference $r_{ls} - r_{lo}$	Difference / P.E. diff.
11	.622 ± .047	13.23
12	.146 ± .046	3.17
13	.237 ± .044	5.38
14	.225 ± .052	4.33
15	.123 ± .051	2.41
16	.166 ± .051	3.26
17	.112 ± .051	2.20
18	.329 ± .052	6.32
19	.252 ± .052	4.84
20	.417 ± .046	9.06
21	.413 ± .050	8.25
22	.011 ± .048	.22
23	.219 ± .052	4.21
24	.174 ± .049	3.56
25	.300 ± .048	6.26
26	.288 ± .049	5.89
27	.173 ± .049	3.54
28	.282 ± .050	5.65
29	.322 ± .050	6.44
30	.360 ± .051	7.05

TABLE IV

$r_{ls} - r_{lo}$ FOR 1907

Number of shrub	Difference $r_{ls} - r_{lo}$	Difference / P.E. diff.
11	.034 ± .080	.43
17	−.235 ± .069	3.39
19	.276 ± .063	4.35
24	.190 ± .052	3.65
29	.270 ± .060	4.50
31	.289 ± .049	5.91
32	.169 ± .059	2.90
33	.245 ± .052	4.73
34	.322 ± .054	5.95
35	.461 ± .059	7.88
36	.091 ± .058	1.58
37	.398 ± .052	7.73
38	.358 ± .052	6.86
39	.204 ± .076	2.70
40	.589 ± .050	11.79
41	.171 ± .067	2.57

For the 16 plants of the 1907 series, the correlation for length and ovules is positive in 13 cases, and negative in 3; significantly negative in one instance, and significantly positive in 11. The values are low, but, as in 1906, there seems to be a slight positive relationship between the length of the pod and the number of ovules formed.

For length and number of seeds all the correlations are positive, and all are significantly positive with regard to their probable errors. Furthermore, they are of a substantial order of magnitude, ranging from 0.150 to 0.500.

Comparing, as in 1906, by taking the differences $r_{ls}-r_{lo}$, with their probable errors as shown in table IV, we find that in one case the difference is negative[7]; of the 15 positive differences, 13 are over 2.5 times their probable error and hence trustworthy.

Diagrams for r_{lo}, r_{ls}, and $r_{ls}-r_{lo}$ make the relationship very clear. Graphs for only one year (1906) need be published. In these diagrams (fig. 1) the vertical line represents the zero line on either side of which the constants would fail if they were due merely to the chance errors of random sampling. The magnitude of the constants for the individuals, or the difference in their correlations, is shown by the length, and the sign by the direction of the bars. The amount of the constant which might be due to the probable errors of random sampling (2.5 times its probable error) is shown by the unshaded area, while the shaded portion gives some idea of the biological trustworthiness of the constant. These diagrams make very clear to the eye that

1. The length of the fruit and both the number of ovules formed and the number of seeds developing are interdependent, and often moderately closely interdependent.

2. The correlation for length and number of seeds per locule is significantly higher than that for length and number of ovules per locule.

3. These two facts taken in conjunction indicate that there is some physiological relationship between the length of the fruit and the number of seeds developing.

[7] It is significantly negative in comparison with its probable error. I find no slip in the arithmetic. The constant is based on only 53 pods, and so too much significance must not be attached to it.

B. DISCUSSION OF DATA FROM GENERAL SAMPLES

In the foregoing section, samples from each tree were treated individually, because heterogeneity of material may have a considerable influence upon correlation. The constant for any single individual cannot be taken to typify *Staphylea trifolia* as a species. Not only is each plant in some measure individual, but the constants based upon a small series of fruits may be too large or too

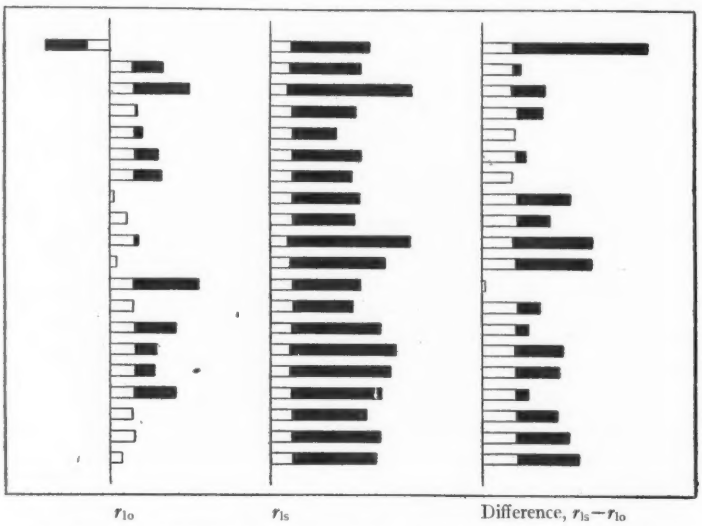

FIG. 1.—Diagram to show intensity of correlation between ovules and length (r_{lo}), seeds and length (r_{ls}), and their difference ($r_{lo}-r_{ls}$), in 20 individuals of *Staphylea;* the individuals are numbered 11 to 30 from the top of the diagram; the length of the bars shows the intensity of the correlation, and the shaded area the statistically significant amount, that is, the excess over 2.5 times the probable error.

small by an amount known as the probable error of random sampling.

To free our constants as far as possible from the influence of probable errors, and to gain more definite conceptions of the actual intensities of our relationships, we may (*a*) examine the means of the constants for the individuals, and (*b*) combine all our subsamples to form one large "population" of 2059 pods (6177 locules) for 1906, and 1218 pods for 1907. Table V contrasts the values

obtained from the lumped samples or "population," with the (unweighted) means of the constants for the several individuals.

The means of the three characters are roughly the same for both methods.[8] The standard deviations of both l and o show large differences. The S.D. is dependent upon the differences of the means of individuals as well as upon the variation among the pods of the same plant, hence the mean S.D. of the individuals is less than that for the combined sample.

TABLE V

COMPARISON OF CONSTANTS FOR GENERAL POPULATION WITH THE MEAN VALUES CALCULATED FROM SAMPLES FROM INDIVIDUALS

	Constants for 1906			Constants for 1907		
	Population	Average	Difference	Population	Average	Difference
Mean ovules	8.1588	8.1538	.0050	7.3716	7.4532	.0816
Standard deviation of ovules	1.1244	.7673	.3571	1.2225	.8065	.4160
Mean seeds	.7149	.7165	.0016	.7427	.7418	.0009
Standard deviation of seeds	.8878	.8462	.0416	.9031	.8665	.0366
Mean length of pod	6.3356	6.3374	.0018	6.7570	6.7453	.0117
Standard deviation of length of pod	1.3663	.9773	.3890	1.3385	.9194	.4191
Correlation, length, and ovules	.0652	.1281	.0629	.0261	.1240	.0979
Correlation, length, and seeds	.3522	.3867	.0345	.2019	.3636	.1617
Correlation, length, and $\frac{\text{seed}}{\text{ovule}}$ index	.3418	.....	.....	.2018	.....	.....

Consider the correlations. For both "populations" r_{ls} is positive, and, while not large, is significant in comparison with its probable error. In both series, r_{lo} is positive, but numerically the values are too small to be of any practical significance. Both r_{lo} and r_{ls} are lower for the general sample than for the means of individuals.[9]

[8] Had the number of pods been the same for all plants, or the plants weighted with the number of pods taken, both methods would necessarily have given the same results.

[9] This result is at first rather puzzling. Generally the combination of several series of material raises r, but it is not necessary that this should always be the case. See footnote in a later section.

The regression straight-line formulae are:

For ovules per locule and length: for 1906, $l = 5.689 + .079\ o$; for 1907, $l = 6.546 + .029\ o$.

For seeds per locule and length: for 1906, $l = 5.948 + .542\ s$; for 1907, $l = 6.535 + .299\ s$.

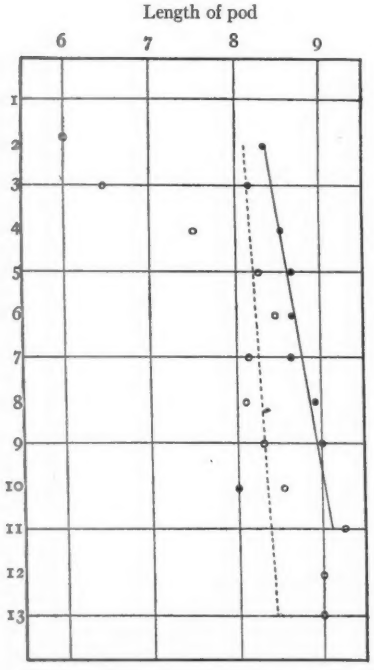

FIG. 2.—Regression of pod length on number of ovules per locule; solid dots and firm line = 1906; circles and broken line = 1907.

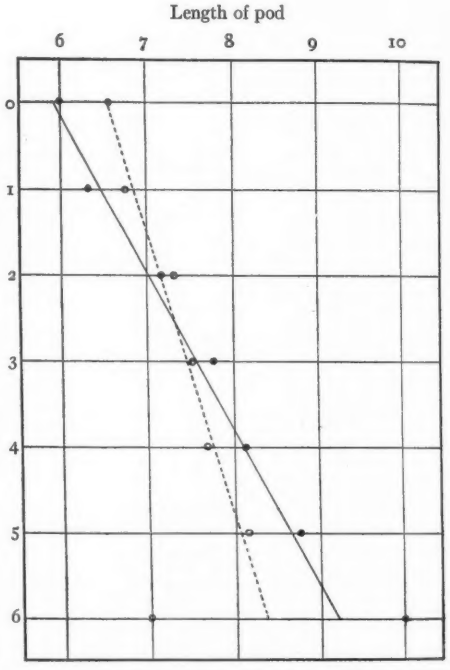

FIG. 3.—Regression of pod length on number of seeds per locule; legend as in fig. 2.

Fig. 2 shows the regression for length on ovules, and fig. 3 that for length on seeds. A straight line seems to represent fairly well the increase in pod length associated with increase in number of seeds. For ovules and length the agreement appears to be very

bad, especially in 1907.[10] These statistical difficulties do not effect the fundamental conclusion to be drawn, and it is in perfect accord with that from the individual shrubs. There is a sensible correlation between length of pod and number of seeds, quite independent of the relationship between number of ovules per locule and length.

TABLE VI

Ovules formed per pod	Length of pod, 1906									
	3	4	5	6	7	8	9	10	11	Totals
15.....	..	..	1	..	..	..	..	..	..	1
16.....	..	..	..	..	..	..	..	..	..	...
17.....	..	1	..	..	2	..	..	..	..	3
18.....	..	4	11	9	2	3	..	..	..	29
19.....	..	7	16	17	8	8	2	..	..	58
20.....	1	8	14	24	19	12	5	..	..	83
21.....	..	2	37	35	24	25	7	..	..	130
22.....	..	7	30	63	33	27	7	..	..	167
23.....	..	14	41	90	69	20	15	2	..	251
24.....	..	35	117	167	108	57	27	7	1	519
25.....	4	20	45	43	46	23	12	1	..	194
26.....	..	12	26	38	34	12	9	3	..	134
27.....	..	10	24	30	29	11	3	5	..	112
28.....	..	6	24	24	16	15	6	5	..	96
29.....	..	7	19	29	27	14	9	4	..	109
30.....	1	8	26	29	36	13	5	4	..	122
31.....	..	..	4	11	3	4	5	..	..	27
32.....	..	..	..	..	4	2	..	1	..	7
33.....	..	1	1	1	1	..	..	..	..	4
34.....	..	..	1	..	1	..	..	..	..	2
35.....	..	..	..	..	..	1	..	..	..	1
36.....	..	..	..	..	..	1	..	..	..	1
Totals	6	142	437	610	462	248	112	32	1	2050

C. TOTAL SEEDS PER FRUIT AND FRUIT LENGTH

The normal fruit of *Staphylea* has three locules. In considering the relationship between fertility and length, should we correlate between the number of ovules or seeds maturing per locule, or should we determine the relationship between the total number

[10] One must remember that classes 7, 8, and 9 exert a powerful influence on the slope of the line, while the extreme classes are represented by so few cases that great irregularity is to be expected, even when dealing with as large numbers as we have here. While a straight line does not represent our empirical means at all well, I cannot see that an equation of a higher order would do any better. Perhaps this irregularity accounts in part for the low value of r_{lo} calculated from the general samples.

per fruit and the length? The length of the three parallel placentae determines in large measure the length of the fruit. From the purely structural point of view, it would seem logical to compute the relationships for the fertility characters of the individual locules. But in testing the assumption that the developing seed exerts some influence upon the growth of the pod, it is important to determine whether there is a closer interdependence between the length and the total seeds developing per fruit than between the length and the number developing per locule. As a basis for comparison the same relationship for total ovules per fruit must also be computed.

The data are: ovules and length, 1906 (table VI) and 1907 (table VII); seeds and length, 1906 (table VIII) and 1907 (table IX). The constants may at once be compared with those calculated by the other methods in table X. For total ovules and length the agreement with the same relationships for individual locules and length in the population is very close. For total seeds and length, the results are somewhat irregular.[11] The logical comparision would seem to be that of the populations rather than that of population for total seeds and the means of individuals for the numbers per locule. For both series this comparison shows a higher correlation when the total seeds developing are used.

We may now determine whether the slope of a straight line adequately describes the change in pod length associated with different degrees of fertility. Only total seeds and length need be considered. The equations are:

For 1906, $l = 5.252 + .505\,s$; for 1907, $l = 6.186 + .256\,s$.

The empirical means and the fitted lines from the above equations are shown graphically in fig. 4. It does not require a trained eye to see that the agreement is not very satisfactory. For the lower seed classes, the length of the fruit increases much more rapidly, and for the higher seed classes much less rapidly than the average rate shown by the slope of the line.

[11] As compared with the population constants for number of seeds per locule and length, both are considerably higher, but when compared with the means of the correlations calculated from the individuals, it appears that the constant for total seeds and length is higher than that for number of seeds per locule and length in 1906, but slightly lower in 1907.

TABLE VII

Ovules formed per pod	Length of pod, 1907								
	4	5	6	7	8	9	10	11	Totals
12	..	..	1	..	..	..	..	..	1
13	..	1	..	..	1	..	..	..	2
14	..	1	3	1	..	..	..	..	5
15	1	1	2	1	..	..	..	..	5
16	..	1	5	5	4	2	..	..	17
17	3	9	13	11	9	5	..	..	50
18	3	15	28	32	24	11	2	..	115
19	..	11	24	39	22	5	2	1	104
20	2	9	23	29	26	7	3	3	102
21	..	12	29	33	18	4	3	..	99
22	2	19	40	19	19	9	3	1	112
23	5	27	33	36	8	11	3	3	126
24	3	55	91	68	31	11	5	1	265
25	2	13	39	17	12	6	2	..	91
26	1	6	14	13	2	2	..	..	38
27	1	2	5	6	7	2	..	..	23
28	..	..	1	7	5	..	..	..	13
29	..	1	2	7	6	2	1	..	19
30	1	..	2	4	6	6	3	..	22
31	..	..	..	1	3	1	..	1	6
32	..	..	..	..	1	..	..	..	1
33	..	..	..	..	..	1	..	..	1
34	..	..	..	..	..	1	..	..	1
Totals	24	183	355	329	204	86	27	10	1218

TABLE VIII

Seeds developing per pod	Length of pod, 1906									
	3	4	5	6	7	8	9	10	11	Totals
0	1	5	2	2	..	..	..	..	..	10
1	5	117	333	344	127	28	2	..	..	956
2	..	17	71	175	150	59	18	2	..	402
3	..	3	19	56	103	65	24	5	..	275
4	..	..	8	19	43	41	31	7	1	150
5	..	..	3	8	26	24	12	1	..	74
6	..	..	1	1	8	16	10	5	..	41
7	..	..	..	2	2	11	8	2	..	25
8	..	..	..	1	1	3	3	5	..	13
9	..	..	..	..	1	..	2	2	..	5
10	..	..	..	2	1	..	..	3	..	6
11	..	..	..	..	..	..	..	..	..	...
12	..	..	..	..	..	1	1	..	..	2
13	..	..	..	..	..	..	..	..	..	...
14	..	..	..	..	..	..	1	..	..	1
Totals	6	142	437	610	462	248	112	32	1	2050

TABLE IX

Seeds developing per pod	Length of pod, 1907								
	4	5	6	7	8	9	10	11	Totals
0	..	2	..	1	..	..	..	..	3
1	21	123	174	138	39	14	10	..	519
2	2	38	99	93	73	17	9	1	332
3	..	15	46	46	41	21	2	4	175
4	..	2	18	24	24	12	..	3	83
5	1	2	9	13	17	7	3	1	53
6	..	..	5	5	4	7	1	..	22
7	..	1	1	3	1	1	2	..	9
8	..	..	2	2	2	5	..	..	11
9	..	..	1	1	1	1	..	..	4
10	..	..	..	..	1	..	..	..	1
11	..	..	..	..	1	..	..	1	2
12	..	..	..	..	..	1	..	..	1
13	..	..	..	..	..	..	..	..	...
14	..	..	..	..	..	..	..	..	...
15	..	..	..	2	..	..	..	..	2
16	..	..	..	1	..	..	..	..	1
Totals	24	183	355	329	204	86	27	10	1218

TABLE X

Comparison of correlations for length and seeds and ovules per locule with those for length and total seeds and ovules per fruit

Relationship	Constants for two years	
	1906	1907
For ovules and length		
Individual locules, means	.1281	.1240
Individual locules, population	.0652 ± .0148	.0261 ± .0193
Total ovules, population	.0729 ± .0148	.0299 ± .0193
For seeds and length		
Individual locules, means	.3867	.3636
Individual locules, population	.3522 ± .0131	.2019 ± .0185
Total seeds, population	.5888 ± .0097	.3235 ± .0173

To test this matter a little further, I have determined the correlation ratio[12] (η) for comparison with the coefficient of correlation.

For 1906, $\eta = .59724 \pm .00958$; for 1907, $\eta = .37720 \pm .01658$
For 1906, $r = .58881 \pm .00973$; for 1907, $r = .32351 \pm .01731$
$\eta - r = .00843$ $\eta - r = .05369$

[12] Pearson, K., On the general theory of skew correlation and non-linear regression. Draper's Company Research Memoirs, Biometric Series, 2. London. 1905.

As constants describing the degree of interdependence between number of seeds developing and length of pod, there seems little to choose between these. To satisfy ourselves more fully concerning

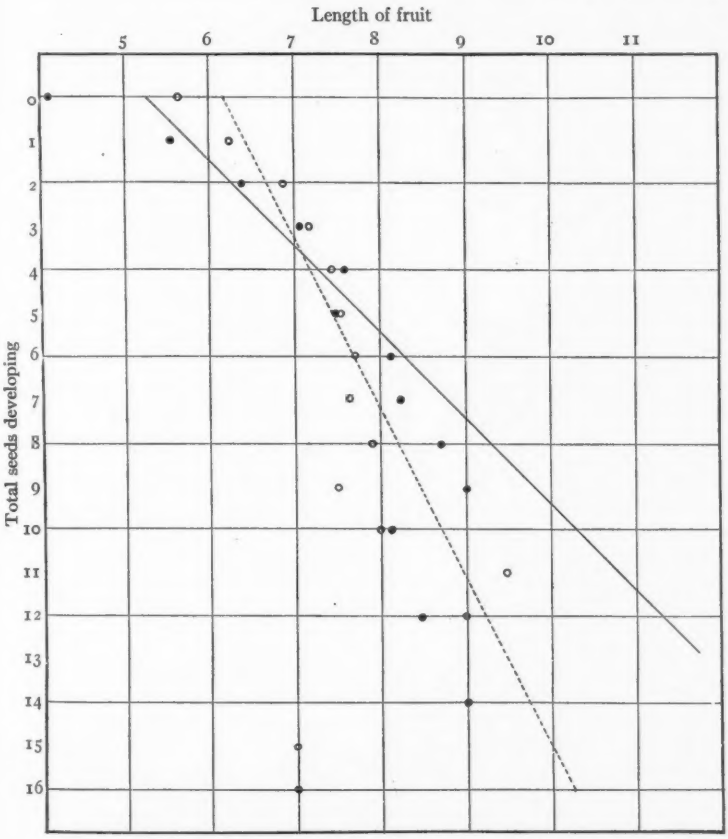

FIG. 4.—Regression of pod length on total number of seeds developing per fruit; solid dots and line = 1906; circles and broken line = 1907.

the rate of change in length of pod, whether it is a simple arithmetical relationship or whether it is some more complex curve, we may calculate ξ and apply BLAKEMAN'S[13] test for linearity of regression.

[13] BLAKEMAN, J., On tests for linearity of regression in frequency distributions. Biometrika 4:332–350. 1905.

$$\xi/E_\xi = \frac{\sqrt{N}}{0.67449} \cdot \tfrac{1}{2}\sqrt{\xi} \cdot \frac{1}{\sqrt{1+(1-\eta^2)^2-(1-r^2)^2}}$$

This gives

For 1906, $\xi = .01000$, $\xi/E_\xi = 3.38$
1907, $\xi = .03762$, $\xi/E_\xi = 5.19$

In both cases $\xi/E_\xi > 2.5$, and regression cannot be safely regarded as linear.[14] Physiologically this indicates that after a certain number of seeds have been formed, the rate of increase in the stimulus to development exerted on the fruit falls off. Something of the same nature has been noticed in *Cercis*,[15] where it appeared that while for the central region of the seed distribution a straight line expressed the change in the pod length very well, pods with a single seed and those with the maximum number of seeds seemed a little smaller in comparison with their number of seeds than the pods of the population as a whole. When better data are available, it will be interesting to investigate this problem in greater detail, but considering the sources of error which have been emphasized above, I see no advantage in further grinding in the mathematical mill. The time would be more profitably spent in collecting other series of data for comparison. The sensibly higher coefficients for total seeds per fruit, as compared with those for seeds per locule, evidence for a direct influence of the seed upon the fruit.

[14] From the graphs one would almost have expected a higher value for ξ/E_ξ, but one of the difficulties in testing linearity of regression in these series is the fact that the frequencies are so concentrated into a few classes. Pods with 1, 2, 3, and 4 seeds form 91.3 per cent of the total in 1906, and 91.1 per cent in 1907. With so few pods falling in the extreme classes, it is difficult to get arrays sufficiently large to give trustworthy averages for testing the goodness or fit of means to any equation. In 1906 there are only 15 classes for 2050 pods, while in 1907 there are 17 classes for 1218 pods. Consequently the mean number of pods per array is less in 1907, and the probable error attaching to these means is greater, thus increasing the value of η by an amount depending on the magnitude of the probable errors. For 1906 the average number for arrays with entries is 157.7 pods, while for 1907 it is only 81.2. The probable errors of the means of arrays, therefore, is much higher in 1907 than in 1906, but there is no method of freeing η from their influence; perhaps these facts explain why ξ/E_ξ is greater in 1907 than for 1906.

[15] Compare the figure in BOT. GAZ. **50**:122. 1910.

CARNEGIE STATION FOR EXPERIMENTAL EVOLUTION
COLD SPRING HARBOR, N.Y.

CONTRIBUTIONS FROM THE ROCKY MOUNTAIN HERBARIUM. X

NEW PLANTS FROM IDAHO[1]

AVEN NELSON

Carex owyheensis, n. sp.—Plants wholly glabrous, single or in small tufts from cormlike rootstocks with an abundance of fibrous roots: culm rather slender, inconspicuously striate, 3–5 dm. high: leaves bright green, few to several, mostly basal with one near the middle of the culm and one or two foliar bracts above, rather short and broad (5–15 cm. long and 6–12 mm. broad), flat, often with acute involute apex: spikes 3–5, in a capitate terminal cluster, and with one or two more or less remote spikes in the axils of foliar bracts, 12–22 mm. long; the bracts of the terminal cluster from lance-acuminate to broadly ovate and obtuse; terminal spike staminate above only: stigmas 3; perigynium membranous, not strongly nerved, narrowly ovate, tapering gradually into the beak which is shorter than the body, pale green with small reddish brown dots below and with the two short, rather soft teeth of the beak dark reddish brown, about 5 mm. long; scale ovate-oblong, obtuse, thin, the pale green center one-nerved, the margins dark reddish brown, much shorter than the perigynium: achene trigonous-ovoid.

This is probably nearest to *C. Raynoldsii* Dew. as regards the technical characters, but in the color and in the grouping of the terminal spikes it is suggestive of *C. viridis* Dew. and *C. multinoda* Bailey. It was secured by MACBRIDE at Silver City, in the Owyhee Mountains, in marshy ground, July 20, 1910, no. 442.

Calochortus cyaneus, n. sp.—Glabrous and somewhat glaucous, rather slender, 3–4 dm. high: bulb small, ovate to oblong, more or less covered with dead flaky scales as is also the base of the nearly straight stem: leaves 3–5, including the 1 or 2 floral ones, narrowly linear, involute, somewhat expanded at the sheathing base, 6–10 cm.

[1] The first paper dealing with the collections of Mr. J. FRANCIS MACBRIDE in Idaho appeared in BOT. GAZ. **52**:261–274. 1911, where there is also a brief outline of the field work and the field covered.

long or the basal one longer: flowers disproportionately large: sepals narrowly linear-lanceolate, 5–6 cm. long, tapering very gradually into the slender tip, bluish green with green midrib and white scarious margins: petals obovate-cuneate (either narrowly or broadly), rather abruptly rounded into the short lanceolate acute tip, as long as or somewhat longer than the sepals, delicate in texture, pale blue with greenish tinge and a narrow green stripe from apex to the gland; gland small, within 5 mm. of the base, bordered at sides and apex with flat yellow hairs, the upper four-fifths of the petal wholly glabrous: anthers yellow, 12–14 mm. long, exceeding the filaments: capsule narrow, nearly as long as the sepals.

Probably most nearly related to *C. macrocarpus* Dougl., from which it is easily distinguished by its slender habit, color of flowers and anthers, and the nearly glabrate petal face. Secured by MACBRIDE on the dry slopes of the foothills of the Boise Mountains, June 18, 1910, no. 268.

Arabis arcoidea, n. sp.—Perennial from a low multicipital caudex surmounting the rather slender woody taproot: stems few to several, simple, slender, erect, 2–5 dm. high, including the long raceme, rather densely short-hirsute below, glabrate above, the pubescence simple or branched (not stellate): leaves entire, crowded-rosulate on the crowns, narrowly linear-spatulate, tapering gradually into the very slender base, 4–6 cm. long (including the base), grayish green with a dense substellate pubescence; stem leaves several, auriculate-clasping at base, smaller, linear, rather distant, gradually reduced to small glabrate bracts above: inflorescence, wholly glabrous: sepals oblong, obtuse, with greenish base and thin purplish tips: petals purplish to violet, spatulate, about 8 mm. long, twice as long as the sepals: stamens scarcely longer than the sepals: pods glabrous, narrowly linear (less than 1.5 mm. broad), 4–6 cm. long, arcuate spreading, on ascending pedicels 5–10 mm. long; seeds in one row, very thin, with wings more than half as broad as the body.

I am unable to refer this to any close ally. If one had only the young plants, one would refer it by reason of the aspect of the basal leaves to *A. canescens* Nutt., to which it may be somewhat related in spite of the very different pods and pubescence. Secured by MACBRIDE at New Plymouth, Canyon County, on dry sandy soils, May 21, 1910, no. 87.

Lupinus multitinctus, n. sp.—Strongly tufted, 4–7 dm. high: stems sparingly branched above, leafy above, the lower stem leaves and most of the root leaves wanting at maturity, from glabrate to minutely pubescent: leaves green, but silvery-silky below, and sparsely pubescent above; petioles slender, the radical and lower cauline several times longer than the leaflets, the uppermost about equalling the leaflets; leaflets 7–11, broadly linear, tapering to the acute ends, 3–5 cm. long: racemes rather slender, dense, 6–12 cm. long; flowers many colored, ranging from nearly white through various shades of yellow to pinks and purples, the individual flowers usually bi- or tri-colored, in 3–5-flowered verticils, on short pedicels which in fruit become 5–8 mm. long; bracts linear, nearly as long as the calyx, caducous: calyx appressed-silky, with thick spur as long as its tube, its lips merely short entire teeth: standard obscurely if at all pubescent, the blade orbicular, about 10 mm. broad, the short base spurred and extending to the base of the calyx spur; wings obovate-elliptic, very delicate, beautifully cross-veined on one side; keel narrow, its darker tip rather conspicuously extruded: pods broad and very flat, densely silvery-silky, with subappressed pubescence, 2–5-seeded.

This new member of the CALCARATI section will most readily be distinguished from the relatively few other spurred species by the beautiful and singular variation in colors shown by the flowers of even a single clump. Like the other members of the section, this shows a slight ciliolation on the middle of the keel. From *L. laxiflorus* Dougl. it may be distinguished by its entire calyx lobes and the more numerous and narrower leaves. No. 114, from steep, north slopes, near Big Willow, near Falk's Store, Canyon County, by MACBRIDE, is typical.

Lotus Macbridei, n. sp.—Glabrous perennial from a short narrowly conical taproot with enlarged crown and numerous semi-fleshy fibrous roots: stems slender and crowded on the crown, widely spreading, or prostrate with assurgent tips, 15–50 cm. long: leaves mostly trifoliate, the petioles 3–8 mm. long; leaflets narrowly oblong or oblanceolate, acute or obtuse, 6–16 mm. long; stipules resembling the leaves and about as large, oblong-lanceolate: flowers a pure yellow, in close almost capitate terminal clusters of 3–7: calyx campanulate, subsessile on the short obconical base,

its lobes narrowly linear-subulate, 2–3 mm. long, as long as the tube: petals obscurely dark veined, with pale claws; the standard about 1 cm. long, its blade suborbicular; the wings as long, obovate with short slender claw; the keel rather narrow, with broadly subulate tip: pods linear, straight, the sutures rather prominent, 20–25 mm. long and 2 mm. broad.

The first collection of this species was secured by MACBRIDE in 1909 and was indicated as new at that time. However, it was deemed wise to withhold publication until a full series of specimens could be secured. No. 227, collected June 7, 1910, is taken as the type. Its range seemed to be rather restricted, but it was found to be quite abundant on wet grassy bottom lands near Falk's Store, in Canyon County.

Astragalus adanus, n. sp.—Root rather large, woody, with branched subterranean crown: stems numerous, rather slender, glabrate, rather coarsely and few-striate, simple, 2–4 dm. high: leaves numerous, narrow, with 13–25 leaflets; the basal 15–20 cm. long including the long almost filiform petiole; cauline leaves shorter and with shorter and slightly stouter petiole; leaflets thin, from oblong to broadly obovate, 7–14 mm. long, glabrous above, sparsely appressed pubescent beneath; stipules short, scarious, ovate-lanceolate: racemes 1–3, few–several-flowered (5–15), axillary in the uppermost leaves on stout peduncles 10–18 cm. long, in fruit much surpassing the subtending leaves; flowers probably ochroleucous: calyx seemingly scarious in part, with scattering black hairs near the base: pod 1–celled, neither suture intruded, thick cartilaginous, the sutures rather prominent, somewhat flattened dorsally, narrowly ovoid with short-acuminate incurved compressed apex, at maturity distinctly cross-ribbed, about 1 cm. long.

This makes the fourth species in the section PECTINATI, the others being *A. pectinatus* (Hook.) Dougl., *A. Grayi* Parry, and *A. nudus* Wats. The leaflets in this species, as in the others, are indistinctly jointed to the rachis, but they are not linear. Since *A. nudus* has violet blue flowers, there seems to be no characters left upon which to rest RYDBERG'S genus *Ctenophyllum* (one of his 17 Colorado segregates of *Astragalus*) except the mode of leaf attachment. The cross-wrinkling of the pods crops out in others of the segregates as well.

The new member of this group comes from the Boise Hills, no. 260 by MACBRIDE, June 18, 1910. The name is based upon the name of the county, which is said to be of Indian origin.

Astragalus boiseanus, n. sp.—Tufted: stems several to many from a woody root, simple, erect, 2–4 dm. high, striate, sparingly appressed-pubescent or glabrate: leaves ascending or suberect, 5–10 cm. long (including the short petiole); leaflets 13–25, oblong, obtuse or slightly emarginate, with an obscure mucro, glabrate above, sparsely appressed strigose beneath, 10–15 mm. long: racemes short, crowded, few-flowered (5–10), on stout axillary peduncles which in fruit elongate to form a flat-topped corymb: calyx tubular, nigrescent, its short lobes subulate: pod stipitate, nearly straight, about 2 cm. long, abruptly acute or acuminate, suberect on the divaricate or ascending pedicel and stipe, the dorsum depressed and with a broad sulcus so intruding the suture as to form a two-celled pod, ventral suture prominent; stipe stoutish, 1 cm. or more long, twice to thrice as long as the calyx.

This has long been referred to *A. arrectus* Gray, to which indeed it is closely related, and the descriptions are alike in many particulars. The plant proposed as new, however, may readily be distinguished by its stouter habit, its shorter leaves and fewer leaflets, its crowded flat-topped appearance in fruit, and more unerringly by the long stipes. In *A. arrectus* the stipe and calyx are subequal, and the more numerous pods in the slender fruiting raceme are more or less appressed to the rachis. Wholly typical of GRAY'S species and nicely representing it are C. V. PIPER'S specimens as follows: Pullman, Wash., July 3, 1903; Palouse Hills, June 30, 1897.

The segregate seems to be the commoner form, and apparently its range is from southern Idaho to Utah and Arizona, but as one may readily be mistaken about specimens in blossom only, I cite only fruiting specimens: C. N. WOODS, no. 4, Caldwell, Idaho, May 1910; FRANCIS MACBRIDE, no. 257, Boise hills, June 18; no. 112 (type), Big Willow, May 27, 1910. The much earlier date at which *A. boiseanus* matures indicates its distinctness from *A. arrectus*.

Astragalus Booneanus, n. sp.—Acaulescent, the woody root with several to many crowns: leaves 6–9 cm. long, crowded on the crowns, hoary with a soft dense tangled (rather than appressed) pubescence, on petioles from one-half to nearly as long as the blade; leaflets 13–21, linear-lanceolate or narrowly oblong, 1 cm. or less long, the lower often alternate: scapes shorter than the leaves, capitately few-flowered: calyx tubular; the tube about 1 cm. long, soon distended by the pod and at length deciduous; its teeth linear, 3 mm. long: corolla violet or purple, the standard 20–25 mm. long,

the blade ovate, the claw broad, channeled or folded, tapering gradually to the base, much longer than the blade; wings oblong, much shorter than the slender claw; the very narrow claws of the keel petals twice as long as their blades: pod thick-coriaceous, obcompressed, ovate, curved, the impressed dorsal suture nearly or quite meeting the ventral, white-hoary with a long soft dense tangled pubescence which is persistent.

This has passed for *A. glareosus* Dougl. and is another case in which species are difficult to distinguish by descriptions alone. These two may be at once separated, however, by the character of the pubescence. In *A. glareosus* it is silky with incumbent appressed hairs, while in *A. Booneanus* it is much denser, looser, and tangled. The pods also are distinguishing in that in the former they are glabrate at maturity; in the latter the shaggy pubescence is permanent.

The species rests upon several very representative collections as follows: President W. J. BOONE, of the College of Idaho, at Caldwell, no. 2, in whose honor the species is named; C. N. WOODS, supervisor Sawtooth National Forest. Hailey, nos. 5 and 25*a*; MERRILL and WILCOX, Leckie, Wyo., no. 583; and J. FRANCIS MACBRIDE, Falk's Store, Idaho, no. 57.

LIGUSTICUM TENUIFOLIUM **dissimilis,** n. var.—What is at least an interesting variety of this species was secured by MACBRIDE in his no. 677, from the Trinity Lake region, August 29, 1910. At first glance one would not suspect any close relationship, but the technical characters show that size and aspect may be misleading. The following points may be enough to distinguish this variety:

Stem naked except for one or at most two reduced bractlike leaves near the inflorescence, 3–5 dm. high: leaves bright green, ternate then pinnate, 1–2 dm. long; petiole one-third to one-half the length; leaflets narrowly to broadly ovate, 15–25 mm. long, pinnately cleft into linear-lanceolate lobes 8–14 mm. long: rays 9–14, 25–40 mm. long; pedicels 8–12 mm. long: fruits essentially as in the species but larger, with longer and stouter stylopodium.

Cornus instoloneus, n. sp.—*Cornus stolonifera* of authors as to western and intermountain specimens; *Suida stolonifera riparia* Rydb. Bull. Torr. Bot. Club **31**:573. 1904; *Suida riparia* in herb; not *Cornus riparia* Rafin.

MACBRIDE having collected a fine series of specimens of this well known species, it became necessary, before labeling for distribution, to look into its present nomenclatural standing. In doing so the writer became convinced that RYDBERG is right in separating the eastern and the western forms. Not only is the western one not stoloniferous, but the leaf distinction is even stronger than as stated by RYDBERG. In the eastern plant the veins are large and cord-like, and appear singularly superficial, a character that does not appear at all in any one of the numerous western specimens examined.

Sambucus ferax, n. sp.—*S. glauca* Nutt. in part. So much has been written on *S. glauca*, and the descriptions by SARGENT (*Man. trees N. Am.* p. 807. 1905) and by BRITTON (*N. Am. trees*, p. 852. 1908) are so full that the plant here proposed as a segregate may best be discriminated by contrast:

It is always a shrub (never treelike) 1–2 dm. high, rarely more: it blossoms and fruits on the season's shoots which have sprung up from the ground as well as on the shoots from the shrubby stems (*S. glauca* is a tree with definite trunk and rounded top): the twigs are glabrous from the first, not pubescent; the pith is slightly brownish, not white: the leaves are smooth from the first and green, not yellowish green: the lanceolate-acuminate leaflets are 7–11, not 5–9, and the teeth are not callous-tipped; they also average much longer, being frequently 15 cm. or more long: the inflorescence is mostly very large, often 3 dm. broad instead of half that size; instead of a single terminal 5-rayed peduncle there are usually or often three 5-rayed peduncles: the flowers are distinctly larger, often 6–7 mm. instead of 3 mm. broad: the fruit is borne in the greatest abundance and seems to observe no regular season, flowers being still seen in great profusion when the first fruits are wholly mature.

The above differences seem sufficient to warrant separating one of the interior shrubby forms from the tree form of the Pacific states. That all the shrubs of the interior should be so separated, I am not prepared to say, but it will not be surprising if careful field study shows that the shrub so common in the interior mountain states is also distinct as well as the one here considered.[2]

The type is MACBRIDE's no. 631 from Trinity, on moist slopes, August 23, 1910, when flowers and fruit were both abundant. The large handsome glaucous berries are excellent for pies or jelly.

[2] Since writing these notes, I have received a copy of M. E. JONES' paper in which the shrub here referred to is published as *S. decipiens* Jones, Bull. Univ. Montana, Biol. Series **15**: 46. 1910.

EUPATORIUM OCCIDENTALE **decemplex,** n. var.—Tufted, the slender stems from the branches of the rhizomatous woody caudex, 3–5 dm. high, pale, slightly puberulent: leaves alternate, rather numerous above, smaller, more distant downward or wanting at base, bright green, thin, obscurely scabro-puberulent, ovate, obtuse or acute, rounded or broadly cuneate at base, short-petioled, rather strongly reticulate veined below, entire to rather coarsely dentate: heads several–many, in a short foliose narrow cymose panicle, puberulent on the bracts and pedicels: involucre tubular-campanulate, 3–4 mm. high, barely half as high as the disk; its bracts linear-oblong, subacute, about 10 and the flowers about the same number, scarcely striate (a midrib and sometimes a pair of faint nerves): corolla rose color, narrowly tubular, about as long as the few scabrous (about 20) pappus bristles and longer than the linear 5-nerved brown achenes.

I have characterized in detail because descriptions of the species available in the manuals are either too brief or else have been gradually so modified as to include some of the forms that seem worthy of being listed separately. The variety here proposed differs primarily in its slender stems, thin bright-green leaves, and the marked uniformity in the number of involucral bracts and rose colored flowers (ten of each). The original collections of the species had 15–25 bracts with white or ochroleucous flowers of about the same number as the bracts.

The more southern form of this, which has so long passed as a variety of *E. occidentale,* is well worthy of specific rank, and I wish so to list it here.

Eupatorium arizonicum (Gray), n. sp.—*E. occidentale arizonicum* Gray, Syn. Fl. 1:101. 1886. This is at once distinct by its aspect, the stoutish stems, more or less branched from the base up, the thickish pale leaves with rather indistinct venation, and more particularly by the several corymbose-cymose clustered whitish flowers on the more or less elongated branchlets, giving a corymbose effect to the whole inflorescence. The leaves are opposite and fairly uniformly truncate-subcordate to deeply cordate at base.

E. arizonicum is far more closely allied to *E. ageratoides* than to *E. occidentale.* This species seems to range from New Mexico to Arizona and north into Nevada and Utah.

Macronema aberrans, n. sp.—Roots woody, rather slender, creeping in rock crevices, their crowns more or less branched: stems

herbaceous, slender, erect, only 5–10 cm. high, glandular-pubescent: leaves granular-glandular-viscid, obovate or oblong or broadly oblanceolate, the blades 1–3 cm. long, obtuse or subacute, mostly sparsely cuspidate-toothed on margin; the lower tapering cuneately into a slender petiole as long as the blade: heads 1–4, 9–14 mm. high, subsessile and subtended by the upper leaves and bracts; involucral bracts broadly linear, in 3 or 4 rows, acute and subcuspidate, green and glandular-viscid at apex, pale and carinate at base: rays wanting; disk flowers numerous, slender: achene cylindric-fusiform, pubescent, about 3 mm. long, about one-third as long as the corolla, which barely exceeds the scabrous pappus.

With the admission of *M. grindelioides* Rydb. and now this species to the genus *Macronema*, the characters of the genus must be modified so as to include toothed as well as entire leaves, and the involucral bracts in even 3–4 series.

No. 641, by MACBRIDE, from Trinity Lake region, Elmore County, August 27, 1910, is the type.

Machaeranthera magna, n. sp.—Grayish-tawny with a minute puberulence and granular-viscid, more strongly upward: stems stout, few to several from a stout biennial root, branched upward and leafy, naked below, 5–10 dm. high: leaves linear, very numerous, more or less involute, 1–3 cm. long, abruptly apiculate with a minute white cusp, margins entire or occasionally a few scattering larger leaves occur and these are sparsely few-toothed: heads numerous on the branched upper half of the plant, terminal and racemosely or spicately disposed on the branchlets, subtended by several foliar bracts: involucre broadly turbinate, 8–10 mm. high, almost as broad, shorter than the disk; its bracts in several series, erect at first but the dark tips at length squarrose or reflexed, minutely white-puberulent and viscid: rays 15–20: achenes densely short-pubescent, shorter than the fuscous pappus which equals the corolla.

At first glance one might think this a gigantic *M. viscosa* Greene if it were not for the small multitudinous linear evidently pubescent leaves, and the unusual viscosity which extends to most of the plant instead of a part of the inflorescence only. The involucral bracts too are more numerous, less reflexed, and only acute (not acuminate).

Type from the sandy bottom lands on the Payette River, near Falk's Store, September 5, 1910, no. 729.

ERIOPHYLLUM GRACILE (Hook.) Gray.—This was listed by PIPER in his *Flora of Washington* as a synonym of *E. integrifolium* (Hook.) Greene (*E. multiflorum* [Nutt.] Rydb.). This he apparently did simply because no one until now has again collected it since TOLMIE'S original specimens, from somewhere in the Snake River country, were secured. MACBRIDE'S no. 137 seems to perfectly represent *E. gracile* as originally described, and I therefore suggest that this name must be retained.

Carduus magnificus, n. sp.—Biennial, very tall (1–2 m.) and strict, moderately stout, or rather slender: stem purplish, often strikingly so, strongly striate, moderately pubescent with long flat jointed straggling hairs, very leafy: leaves glabrate above, tomentose beneath, broadly linear in outline, 1–3 dm. long, the bordered midrib 7–15 mm. wide, the rather numerous spinous pinnae 12–25 mm. long, 1–3-lobed or parted, the lobes mostly lanceolate or broader: heads few to several, racemosely disposed on short branchlets successively shorter to sessile above, 4–6 cm. high and broad, subtended by several to many linear purplish foliar bracts which often well surpass the heads: involucral bracts numerous, in several series, green but sparsely pubescent on the margins; the outer with rather weak spines; the inner with elongated, dilated, crimped or fringed tips: flowers a rich purple, very numerous and slender; corolla tube scarcely as long as the limb which is cleft halfway into 5 filiform lobes: styles well exserted: achenes 5–6 mm. long, narrowly oblong or linear-spatulate, brown, glabrous or almost polished, the conspicuous stylophore encircled by a raised yellowish white collar-like border: pappus bristles very soft, sparsely and delicately plumose except the tips.

This falls into the section ECHINAIS Cass, DC., and the section CARLINOIDES of RYDBERG'S Colorado list, but it evidently is not closely related to any of the species heretofore known. MACBRIDE reports this plant as scattering on a wet saline flat near Falk's Store, Canyon County, Idaho. No 271, June 22, 1910, is the type.

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THE RELATIVE WILTING COEFFICIENTS FOR DIFFERENT PLANTS[1]

LYMAN J. BRIGGS AND H. L. SHANTZ[2]

The wide range in moisture content of different soils at the time of wilting of the plant cover appears to have been first clearly recognized by SACHS[3] in 1859. Later investigators, in extending this work, concluded that not only do soils show a wide range in moisture retentiveness, but that different groups of plants differ widely in their ability to reduce the moisture content of a given soil. Thus, the experimental work of GAIN,[4] HEINRICH,[5] HEDGCOCK,[6] and CLEMENTS[7], all indicates considerable variation in the moisture content of the soil at the time of wilting of different plants, which has been interpreted to mean that some plants are capable of reducing the moisture content of a given soil to a lower point than others; in other words, that the "non-available moisture" varies according to the kind of plant used as an indicator. In fact, this is the view which is usually presented in many of the standard works on plant physiology and plant ecology.

The difference exhibited by plants in this respect has also been

[1] Published with the permission of the Secretary of Agriculture.

[2] For discussion of methods and additional matter, see BRIGGS, L. J., and SHANTZ, H. L., A wax seal method for determining the lower limit of available soil moisture. BOT. GAZ. **51**:210–219. 1911.

The wilting coefficient for different plants and its indirect determination. U.S. Department Agric. Bur. Pl. Ind. Bull. 230. 1912.

The wilting coefficient and its indirect determination. BOT. GAZ. **53**:20–37. 1912.

[3] SACHS, J., Berichte über die physiologische Thätigkeit an der Versuchstation in Tharandt. Landw. Versuchs. Stat. **1**:235. 1859.

[4] GAIN, E., Action de l'eau du sol sur la vegetation. Rev. Gen. Bot. **7**:73. 1895.

[5] HEINRICH, R., Zweite Bericht über die Verhaltnisse und Wirksamkeit des Landwirtshaftlichen Versuchs-Station zu Rostock. 1894: 29.

[6] HEDGCOCK, G. G., The relation of the water content of the soil to certain plants, principally mesophytes. Bot. Surv. Neb. VI. Studies in the vegetation of the state. II. 1902: 5–79.

[7] CLEMENTS, F. E., Research methods in Ecology. 1905: 30.

considered to be an important factor in drought resistance, the additional supply of water thus made available to some plants being supposed to be sufficient to carry them through a dry period when other plants would succumb to drought. With this point of view in mind, the present writers have made an extensive series of determinations with a number of plants, including native plants from semi-arid and arid regions, to determine the variation exhibited in their ability to reduce the moisture content of the soil before permanent wilting takes place. The results of these investigations have led us to conclude that the variation exhibited by different plants is much less than has heretofore been supposed, and that it is insignificant compared with the range in moisture retentiveness exhibited by different soils.

The observations given in the following table embrace about 1300 observations made with plants growing in 20 different types of soil. The actual wilting coefficients as observed range from less than 1 per cent in the case of the dune sands to 17 per cent for the clay loam. In order to reduce the results of these observations to a comparable basis, the relative wilting coefficient has been determined by taking the ratio of each individual determination to the mean of all the determinations made with that soil. If the wilting coefficient for a particular plant is higher than the average, the ratio will be greater than unity. If, on the other hand, a plant is capable of reducing the moisture content below the point attained by other varieties before wilting occurs, then the ratio will be less than unity. In this way it is possible to combine all the observations made upon different soils and to determine the extent to which any particular plant is able to reduce the soil moisture content below the point reached by other plants before wilting occurs.

It will be seen from table I that the extreme values of the relative wilting coefficient for all plants upon which six or more determinations are made are represented by 0.92 for Japan rice and 1.13 for *Colocasia*. The latter plant has an extremely coarse root system, the fine fibrous roots so characteristic of the grasses being wholly absent. A plant with a root system of this kind does not reduce the water content of the soil uniformly. At the time

TABLE I

THE RELATIVE WILTING COEFFICIENTS FOR DIFFERENT VARIETIES

Plant	Variety	No.	No. of obs.	Mean ratio	Probable error of mean ratio	Probable error of single observation
Zea mays...	Boone Co. white	United States	..	..	.....	.....
	.....	selection 119...	33	1.00	0.007	0.038
	Esperanza.....	M 66.....	16	1.06	0.013	0.052
	Minn. 13.....	United States selection 133...	3	1.03	.....	.....
	Hopi.....	A 7.....	3	1.05	.....	.....
	United States selection....	165.....	4	1.00	.....	.....
	Indian flint....	.....	3	1.08	.....	.....
	Northwestern dent.....	.....	4	1.09	.....	.....
	Laguna.....	.....	4	1.05	.....	.....
	Chico.....	M 72.....	2	1.06	.....	.....
	Iowa silver mine.....	.....	3	1.06	.....	.....
	Chinese.....	S.P.I. 22308 ..	3	1.03	.....	.....
Andropogon sorghum...	White durra...	S.P.I. 24997...	17	0.94	0.012	0.052
	Dwarf milo....	S.P.I. 24970...	17	0.994	0.017	0.072
	Red amber ...	S.P.I. 17543...	7	0.94	0.007	0.044
	Black amber...	Minn. 341.....	12	1.00	0.026	0.089
	Red kafir.....	S.P.I 24985....	3	1.01		
	Black-hull kafir.....	S.P.I. 24975...	3	1.03	.....	.....
	Dagdi durra...	S.P.I. 9856....	3	1.02	.....	.....
	Black-hull kowliang.....	G.I. 310.....	3	1.03	.....	.....
	Brown kowliang.....	S.P.I. 24993...	1	1.04	.....	.....
Chaetochloa italica.....	Kursk.....	S.P.I. 22420...	27	0.954	0.008	0.040
	Common.....	S.P.I. 22423...	6	0.96	0.011	0.027
	Siberian.....	S.P.I. 21076...	6	1.01	0.009	0.023
	German.....	S.P.I. 26845...	3	1.00	.....	.....
	Chaetochloa italica.....	S.P.I. 21073...	3	1.04	.....	.....
Panicum miliaceum.	Proso.....	G.I. 72.....	3	0.99	.....	.....
Triticum durum....	Kubanka.....	G.I. 1440.....	593	1.00	0.0021	0.051
	Kubanka.....	G.I. 1354.....	3	0.94	.....	.....
	Kubanka.....	G.I. 2246.....	3	0.97	.....	.....
	Yellow ghar-novka.....	S.P.I. 26008...	3	0.94	.....	.....
	Yellow ghar-novka.....	G.I. 1444.....	3	0.96	.....	.....
	Pelissier.....	G.I. 1584.....	3	0.97	.....	.....
Triticum vulgare....	Bluestem.....	Minn. 169.....	28	0.96	0.0066	0.035
	Turkey red....	G.I. 1558.....	11	0.99	0.0116	0.038
	Fretes.....	S.P.I. 19239...	3	0.94	.....	.....
	Power's fife....	G.I. 3025.....	3	0.95	.....	.....

TABLE I—*Continued*

Plant	Variety	No.	No. of obs.	Mean ratio	Probable error of mean ratio	Probable error of single observation
Triticum dicoccum	Spring emmer	S.P.I. 19907	3	1.07	.....	.....
Avena sativa	Kherson	G.I. 459	15	1.03	0.0149	0.058
	Swedish select.	S.P.I. 24877	13	0.984	0.009	0.033
	Canadian	S.P.I. 12880	3	0.96	.....	.....
	75 day	G.I. 337	3	1.02	.....	.....
	60 day	G.I. 639	3	1.04	.....	.....
	Big 4	G.I. 558	3	1.03	.....	.....
	Burt	S.P.I. 24670	3	0.93	.....	.....
	Red rust proof	G.I. 458	3	0.92	.....	.....
Hordeum distichon	White smyrna	G.I. 195	3	0.94	.....	.....
	Hannchen	G.I. 531	18	0.98	0.011	0.047
	Unknown	.....	16	0.98	0.013	0.034
Hordeum vulgare	Beldi	G.I. 190	14	0.97	0.013	0.054
	Telli	G.I. 194	3	0.92	.....	.....
	Mariut	G.I. 261	3	0.95	.....	.....
	Oderbrucker	S.P.I. 26105	2	0.92	.....	.....
	Hull-less	S.P.I. 12709	1	0.91	.....	.....
Secale cereale	Giant winter rye	.....	19	0.94	0.011	0.049
Oryza sativa	Japan	G.I. 1642	15	0.92	0.014	0.054
	Carolina golden	G.I. 1645	3	0.96	.....	.....
	Honduras	G.I. 1643	3	1.03	.....	.....
Gramineae	Bromus inermis	.....	33	0.94	0.005	0.028
	Agropyron Smithii	.....	11	1.03	0.013	0.043
	Agropyron tenerum	.....	15	0.99	0.013	0.052
	Agropyron cristatum	.....	6	0.96	0.013	0.032
	Elymus canadensis	.....	3	1.00	.....	.....
	Stipa Vaseyi	.....	3	0.99	.....	.....
	Sitanion hystrix	.....	3	0.97	.....	.....
	Aristida longiseta	.....	2	1.00	.....	.....
	Bouteloua oligostachya	.....	1	1.01	.....	.....
Leguminosae	Medicago sativa	S.P.I. 25695	33	0.98	0.006	0.035
	Vicia villosa	S.P.I. 25935	17	1.04	0.013	0.053
	Vicia faba	S.P.I. 15428	23	1.02	0.016	0.078
	Pisum arvense	S.P.I. 19389	28	1.05	0.012	0.064
	Melilotus alba	S.P.I. 21216	8	1.03	0.012	0.033
	Vicia fulgens	S.P.I. 21502	6	0.93	.....	.....
	Vicia atropurpurea	S.P.I. 18132	3	1.05	.....	.....
	Vicia ervilia	S.P.I. 16137	3	0.92	.....	.....
	Cicer arietinum	S.P.I. 24322	3	0.93	.....	.....
	Vigna unguiculata	S.P.I. 26497	3	0.98	.....	.....
	Trifolium pratense	.....	5	1.04	.....	.....

TABLE I—*Continued*

Plant	Variety	No.	No. of obs.	Mean ratio	Probable error of mean ratio	Probable error of single observation
Leguminosae	Onobrychis viciaefolia	S.P.I. 24931	3	1.00	.....	.....
	Lupinus pusillus	.....	2	0.97	.....	.....
Cucurbitaceae	Cucurbita pepo	.....	15	1.01	0.018	0.073
	Cucumis sativa.	.....	1	0.90	.....	.....
	Cucumis melo	.....	1	1.04	.....	.....
Lycopersicon esculentum	Livingston	.....	17	1.05	0.011	0.043
	Stone	.....	3	1.08	.....	.....
Colocasia	.....	S.P.I. 21190	19	1.13	0.015	0.059
Mesophytes	Ipomoea purpurea	.....	3	1.11	.....	.....
	Plantago lanceolata	.....	2	1.06	.....	.....
	Citrus limonum	.....	1	0.96	.....	.....
	Abutilon striatum	.....	2	0.91	.....	.....
	Gossypium hirsutum	.....	2	1.05	.....	.....
	Coleus	.....	5	0.99	.....	.....
	Lactuca sativa	.....	3	1.11		
	Solanum tuberosum	.....	3	1.06	.....	.....
	Fagopyrum vulgare	.....	1	1.05	.....	.....
	Beta vulgaris	.....	3	1.06	.....	.....
	Linum usitatissimum	.....	2	0.99	.....	.....
	Brassica napus	.....	3	0.94	.....	.....
	Amaranthus retroflexus	.....	5	1.01	.....	.....
Xerophytes	Grindelia squarrosa	.....	4	1.08	.....	.....
	Vernonia marginata	.....	3	1.04	.....	.....
	Artemisia gnaphalodes	.....	6	1.06	.....	.....
	Pachyphytum aduncum	.....	1	1.03	.....	.....
	Echeveria pubescens	.....	1	1.10	.....	.....
	Nopalea cochinelifera	.....	1	1.03	.....	.....
Hydrophytes	Ranunculus septentrionalis	.....	2	0.98	.....	.....
	Juncus balticus	.....	1	1.07	.....	.....
	Nasturtium	.....	3	1.03	.....	.....
	Isoetes saccharata	.....	2	1.33	.....	.....
Weighted mean	.....	.....	..	1.00	.....	0.054

the plant wilts, the soil farthest from the roots contains more water than the soil immediately surrounding the roots. Consequently, the determination of the moisture content of the whole soil mass at the time of wilting gives too high a value for the wilting coefficient. Aside from the *Colocasia*, a variety of corn gave the highest relative wilting coefficient, namely, 1.06. The several varieties of corn differed slightly, the lowest value being given by Boone County white, a variety native to wet regions. Mexican and Indian varieties, natives of dry regions, gave no evidence of being able to reduce the soil moisture content lower than other varieties. Only slight differences were found in the relative wilting coefficient in the different varieties of sorghum, a crop extensively grown in semi-arid regions. The relative wilting coefficient of two of the varieties tested was 0.94, indicating that these varieties were capable of reducing the moisture content of the soil somewhat below the point reached by corn at the time of wilting. The difference in the wilting coefficient of the varieties of the small-grain crops, millet, wheat, oats, and barley, is slight, the extreme range for the four crops being from 0.95 to 1.03. The value of the wilting coefficient obtained for rye was 0.94 and for Japan rice 0.92. The low value found for the latter plant is of special interest in view of the fact that it is generally considered necessary to keep rice fields flooded during the greater part of the growing season.

The different grasses, most of which are natives of the Great Plains of the United States, gave ratios differing only slightly from each other and from the small grains. Most of the legumes, on the other hand, and certain of the coarse-rooted plants of the Great Plains, gave slightly higher values for the relative wilting coefficient. These high values, we believe, are to be attributed to imperfect root distribution rather than to any inherent inability of these plants to reduce the soil moisture content to the point reached by other plants.

The miscellaneous plants upon which only a few determinations have been made are grouped in the last part of the table as hydrophytes, mesophytes, and xerophytes. The water plants gave a mean wilting coefficient slightly higher than the other groups, due to the presence in this group of *Isoetes*, submerged plants of which

were taken from the water and grown in the air without being permitted to develop new leaves. This plant also had a poor root distribution. If we except *Isoetes*, the other hydrophytes give a mean wilting coefficient identical with that of the mesophytes. The xerophytes tested gave a mean ratio intermediate between the hydrophytes and mesophytes. This would indicate that plants native to dry regions are unable to reduce the water content of the soil to a lower point than is reached by other plants at the time of wilting.

TABLE II

THE RELATIVE WILTING COEFFICIENT FOR DIFFERENT PLANTS

PLANT	NO. OF OBSERVATIONS	MEAN RATIO	PROBABLE ERROR	
			Of mean ratio	Of single ratio
Zea	75	1.03	0.003	0.042
Andropogon	66	0.98	0.008	0.062
Chaetochloa italica	48	0.97	0.006	0.035
Triticum	653	0.994	0.002	0.049
Avena	46	0.995	0.007	0.047
Hordeum	60	0.97	0.006	0.047
Secale	19	0.94	0.011	0.049
Oryza	21	0.94	0.012	0.054
Gramineae	77	0.97	0.005	0.040
Leguminosae	138	1.01	0.005	0.059
Cucurbitaceae	17	0.99	0.016	0.068
Lycopersicon	20	1.06	0.009	0.040
Colocasia	19	1.13	0.005	0.066
Hydrophytes	8	1.10	0.037	0.105
Mesophytes	35	1.02	0.010	0.058
Xerophytes	16	1.06	0.008	0.032
Total number of observations	1,318	.....	.....	.....
Weighted mean	.....	1.00	.....	.....

The results of the different crops have been summarized in table II without reference to varieties. Reference to the table will show that only slight differences exist among the various crops in their ability to reduce the soil moisture content before wilting occurs. Sorghum, millet, wheat, oats, barley, and the grasses are practically the same. Rye and rice appear to be a little lower than the mean, corn and the legumes slightly higher.

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ALTERNATION OF GENERATIONS IN CERTAIN FLORIDEAE

I. F. Lewis

Cytological observations on *Polysiphonia* by Yamanouchi[1], *Griffithsia* by myself,[2] and *Delesseria* by Svedelius,[3] render it probable that in these genera at least, and presumably in all Florideae in which tetraspores and sexual organs are regularly borne on separate individuals, there exists an alternation of sexual and asexual plants, the carpospores giving rise on germination to asexual, and the tetraspores to sexual individuals. For the past two summers at Wood's Hole I have been engaged in putting this matter to the proof by actual cultivation of the sporelings to maturity. This would seem to be a simple matter, but experience has shown me, as it has many others, that the range of physiological tolerance of these forms is extremely small. Temperature, light, and other less easily regulated factors may vary only within very narrow limits. All attempts to carry sporelings to maturity in the laboratory having failed, a plan was adopted similar to that employed by Hoyt[4] in solving an analogous problem in Dictyota.

The method consisted in sowing spores on oyster shells, and transferring these to the open water after the sporelings had become firmly attached. The shells were soaked for at least 24 hours in fresh water and then scraped clean with a brush. Three small holes were made in each to facilitate its subsequent attachment. The shells so prepared were placed in deep glass vessels in filtered sea water. Fruiting algae of the desired species were then washed in running water for a few minutes, and placed in the vessels over

[1] Yamanouchi, S., The life history of *Polysiphonia*. Bot. Gaz. **42**:401–449. 1906.

[2] Lewis, I. F., The life history of *Griffithsia Bornetiana*. Ann. Botany **23**:639–690. 1909.

[3] Svedelius, N., Ueber den Generationswechsel bei *Delesseria sanguinea*. Svensk Botanisk Tidskrift **5**:260–324. 1911.

[4] Hoyt, W. D., Alternation of generations and sexuality in *Dictyota dichotoma*. Bot. Gaz. **49**:55–57. 1910.

the shells. This was usually done in the afternoon, and the algae taken out the next morning. The spores of most species were shed in abundance, the resulting sporelings becoming attached almost immediately. At first the dishes were kept in the laboratory till the sporelings had become about 2 mm. long, and the shells were then transferred to the waters of Vineyard Sound. In such cases, however, the sudden change of environment exerted a deleterious effect on growth. For this reason, in all the later experiments the shells were transferred on the second day after the spores were shed. This was found to allow ample time for firm attachment of the sporelings. Each shell, before being "planted," was minutely inspected with a lens, and only those were used which showed a good uniform "stand" of sporelings without visible contamination from the spores of other species. Close inspection was especially necessary in the case of *Griffithsia* and various species of the Rhodomelaceae, on account of the frequency in these forms of vegetative multiplication from the broken off tips of the filaments. No attempt to thin out the sporelings was made.

Tarred cord, first soaked for some months in salt water to extract the soluble matter in the tar, was used for attaching the shells. A sort of ladder was made by having two parallel cords about 6 inches apart, to which shells were tied by cord running from the three holes mentioned. A ladder prepared in this way was either stretched horizontally between two supports, such as stakes firmly driven into the bottom or allowed to hang vertically from a pile. In the latter case the parallel cords were weighted at the bottom, to prevent the ladder from becoming tangled by the tidal currents. The latter method proved more satisfactory, as in this way, by having a series of shells bearing sporelings of one species, the optimum depth for the growth of that species could be readily determined. This was found to vary with the species employed, but in general it was about 2–3 feet below mean low water.

Plantations were made at Spindle Ledge, on the piles of the Government Wharf at Little Harbor, and on the piles at the end of the Fay Wharf. The best results were obtained at the last mentioned locality. The water here is very deep, the outermost

piles standing in the edge of the main channel. The rapid flow of the tides, and perhaps other factors, seem to prevent the attachment of spores, so that the algal flora at this point is quite scanty. This was found to be of importance for the reason that shells placed here showed almost no contamination from unknown sources, while at the other localities foreign spores settled and grew so abundantly and luxuriantly that the planted spores were overcrowded. Furthermore, at Spindle Ledge a considerable mass of drift, consisting for the most part of tangled mats of *Ectocarpus*, caught on the cords and prevented the development of the algae sown. In all, about 125 shells were planted.

The plantations were all made in July. The shells were left in the water 21–45 days. It was found, however, that in those species in which definite results were obtained, little if any growth took place after August 15. On all shells taken up as late as September 1, the algae were found to be disintegrating. After being collected, each shell was examined with the greatest care. Every visible growth, animal or plant, was scraped off and minutely inspected under the compound microscope. In this way possibility of error of observation was eliminated as far as could be done. In the course of the microscopic examinations, many observations were recorded as to the rate of growth of various species, the relative abundance of spores at different localities, and other matters not included within the scope of the present paper.

The following species were used: *Spermothamnion Turneri* Aresch., *Callithamnion Baileyi* Harv., *Griffithsia Bornetiana* Farlow, *Ceramium rubrum* Ag., *Ceramium fastigiatum* Harv., *Cystoclonium purpurascens* Kütz., *Chondrus crispus* (L.) Stack., *Lomentaria uncinata* Menegh., *Champia parvula* (Ag.) Harv., *Agardhiella tenera* (J. Ag.) Schmitz, *Grinnellia americana* Harv., *Gracilaria multipartita* J. Ag., *Chondria tenuissima* (Ag.) Harv., *C. dasyphila* (Ag.) Harv., *Polysiphonia fibrillosa* Grev., *P. violacea* Grev., *Dasya elegans* Ag. (17 species). Of these, the majority proved to be unsuitable, definitive results being obtained only with *Polysiphonia violacea*, *Griffithsia*, and *Dasya*. The failure to obtain results with some was due to lack of proper environment, since no shells were planted in deep water where such forms as *Gracilaria*, *Spermotham-*

nion, and *Cystoclonium* are found. In other cases, as *Chondrus* and *Agardhiella*, growth of the sporelings was so slow that they became covered and killed by the growth of exotic spores. In still others, the sporelings failed to become established, even the short time in which they were under laboratory conditions being sufficient to cause them to cease growing. Strange to say, some of these, as *Ceramium rubrum* and *Chondria tenuissima*, seem to be quite hardy, and are abundant and luxuriant in situations similar to those in which the shells were planted. Still others, including *Champia* and *Lomentaria*, were early discarded because of the frequency with which these species establish themselves on any suitable solid support.

Record of experiments

I. *Agardhiella tenera*.—Tetraspores and carpospores sown July 18, 1910, transferred to Spindle Ledge July 19. Shells collected August 10, and found to be much overgrown with foreign algae. Search revealed hundreds of small sterile *Agardhiella* plants, of which the average length was 0.5 mm. Some were of good color and apparently vigorous, but the great majority had ceased growing and were beginning to become discolored. The most interesting point about this culture was the fact that the sporelings from carpospores and tetraspores were of exactly the same size and conformation.

II. *Grinnellia americana*.—Treatment like that of *Agardhiella*. Hundreds of sterile specimens were found, 3–4 mm. long, vigorous and of good color. The fact that the amount of growth in 24 days at the height of the growing season was so slight would seem to indicate that this species, like the preceding one, is biennial, the sporelings of one summer reaching maturity the next year.

III. *Polysiphonia violacea*.—Tetraspores and carpospores sown July 18, 1911, transferred to piles at end of Fay Wharf July 20, collected August 14. The shells sown with tetraspores were accidentally destroyed before being collected. On examination, the shells sown with carpospores were found to be pretty thickly overgrown with *Polysiphonia variegata*, mostly sexual. Scattered among these plants, however, were 29 individuals of *P. violacea*, varying in length from 1.0 to 3.1 cm. The color of all was darker

than usual, and the plants seemed to be stunted. The main branches ended much more abruptly than is common in this species, and the development of hairs was sparse. The apices, however, were normal, and the plants still growing. All the smaller individuals, 23 in number, were found to be sterile, but 6, comprising the largest specimens, bore tetraspores normally and abundantly. On neighboring shells, which were examined very carefully as controls, no *P. violacea* was found. The only contaminating species were *P. variegata* in great numbers, *Champia parvula* (averaging 3 individuals to each shell), and *Dasya elegans* (2 per shell). It may be remarked parenthetically that *P. violacea* and *P. variegata* are species that are quite distinct, and easily and surely recognizable.

In this experiment, carpospores were found to produce tetrasporic plants, and no sexual individuals.

IV. *Griffithsia Bornetiana*.—Carpospores sown July 18, 1910, transferred to Spindle Ledge July 19, shells collected August 12. The stand of *Griffithsia* was found to be unusually good, the shells resembling miniature lawns on which *Griffithsia* was the grass. The individuals were so closely appressed and interwoven at the base that it was impossible to ascertain the exact number, which must, however, have reached into the hundreds. The largest were about 2 cm. long, a size at which sexual individuals fruit fairly abundantly, but all were sterile.

Tetraspores sown July 2, transferred to Spindle Ledge July 18, 1910, shells collected August 10. The maximum length attained was 1.5 cm., and the average 0.75 cm. Numerous very small sterile individuals were found. Of those specimens which had attained a length of 1.0 cm., 23 showed developing sexual organs, and 7 were sterile. Of the sexual plants, 12 were male and 11 female. Neighboring shells used as controls were destitute of *Griffithsia*. The results of this experiment were confirmed by cultures made in 1911. Tetraspores from a single plant were sown July 15, transferred to piles at Little Harbor July 18, shells collected August 14. The largest individuals were stocky, bushy plants 3 cm. long, and all were well developed, there being little crowding with the resulting production of dwarfed specimens. From one shell 45 individuals were obtained, of which 8 were sterile,

20 male, and 17 female. In the female plants ripe carpospores were being produced at the time of collection. Neighboring shells, as before, showed no *Griffithsia*. The contaminating species were *Champia parvula* (5 per shell), *Lomentaria uncinata* (4), *Grinnellia americana* (1), and *Polysiphonia variegata* (1).

A very interesting feature of this culture was the occurrence of two large apparently hermaphroditic individuals. In each case, close inspection revealed the fact that the apparently single individual was really a complex of four plants in intimate contact at the base. The rhizoidal filaments were interwoven somewhat, but could be separated with needles. Of the four, two were male, two female. The four spores from one tetrasporangium of *Griffithsia* frequently remain in contact after being shed, so that four spores may often be seen lying in immediate proximity, all derived from the same sporangium. In the cases mentioned, it seems as if this must have happened, and the four individuals composing the single compound plant have been derived from the four spores of a single sporangium. Further experiments will be made to settle this point.

V. *Dasya elegans*.—Carpospores could not be obtained early enough in the season to give positive results. Tetraspores sown July 18, 1911, transferred to Fay Wharf July 19, shells collected August 14. The stand of *Dasya* was quite good, but the individuals remained clearly separate, not running together at the base as in the case of *Griffithsia*. The largest specimens measured 4.5 cm. long, with 6 or 8 side branches from the main stem. The average length was 2 cm. Of the largest and best developed specimens, measuring more than 3 cm. in length, 6 were female, 7 male, and 1 sterile. Of the total number of individuals, 139 were sterile, 143 male, and 6 female. In interpreting this result, it is necessary to bear in mind that antheridia may develop when the plants are quite small (0.5 cm. long or in exceptional cases even less), while procarps do not begin to form in individuals less than about 3 cm. long. On control shells no *Dasya* developed. The most abundant contaminating species was *Polysiphonia variegata*, while *Champia parvula*, *Ceramium rubrum*, *Chondria tenuissima*, and *C. dasyphila*, along with *Enteromorpha* sp., occurred rarely.

What may be called the reciprocal cultivation of a single species has not yet been attended with success. It is more difficult to raise carposporelings to maturity than tetrasporelings, for the reason that tetrasporic plants are usually late in fruiting, while sexual individuals may be expected to produce reproductive bodies in 3–5 weeks. The experiments in their present status show, however, that in *Griffithsia* and *Dasya* the tetraspores actually do produce sexual plants, and only these, and that in *Polysiphonia violacea* carpospores produce only tetrasporic plants. The results of the experiments go to show, therefore, that the conclusions drawn from cytological evidence are valid, and that alternation of sexual and tetrasporic plants in the Florideae is now an observed fact.

In conclusion, it is a pleasure to acknowledge my indebtedness to the friends who have assisted me in various ways in the progress of this work, particularly Professor GEO. T. MOORE, Dr. ERNST A. BESSEY, Mr. H. WASTENEYS, and the officers of the Supply Department of the Marine Biological Laboratory.

Summary

1. There is no evidence that the double number of chromosomes in the carpospores imparts greater vigor of growth as compared with the single number of the tetraspores.

2. From the carpospores of *Polysiphonia violacea* 6 tetrasporic plants were obtained, and none sexual.

3. From the tetraspores of *Griffithsia Bornetiana* 60 sexual individuals were produced, and none tetrasporic.

4. From the tetraspores of *Dasya elegans* 149 sexual plants were secured, and none tetrasporic.

5. Tetraspores from a single individual produced male and female plants in approximately equal numbers in *Griffithsia*. The preponderance of males in *Dasya* is explained by the early fruiting of these as compared with the females.

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A STUDY OF HYBRIDS BETWEEN NICOTIANA BIGELOVII AND N. QUADRIVALVIS[1]

E. M. EAST

(WITH FOUR FIGURES)

The genus *Nicotiana* was divided by G. DON into four sections: TABACUM, RUSTICA, PETUNIODES, and POLIDICLIA. This classification has been followed in all *Nicotiana* monographs down to the present day, although several species have been shifted back and forth. The section POLIDICLIA is based upon *Nicotiana quadrivalvis* Pursh (Lehm. *Gen. Nic. Hist. pl. 4*) and its variety *multivalvis* Gray (*Syn. Fl. N. Amer.* **2**[1]: p. 253). (See COMES' *Monographie du genre Nicotiana*. Naples. 1899, p. 54.) The experiments on *N. Bigelovii* Watson and *N. quadrivalvis* Pursh reported in this paper show that such a section is unwarranted.

The writer began an extended series of genetic investigations upon the species of the genus *Nicotiana* in 1907 at the Connecticut Agricultural Experiment Station. Seed of several species was very generously given by Professor O. COMES of Naples, Italy, through Dr. D. G. FAIRCHILD of the United States Department of Agriculture; by Dr. A. SPLENDORE of Scafati, Italy; and by Professor W. A. SETCHELL[2] of the University of California. The source of the seed from Italy is unknown to me, but several of the species obtained from Professor SETCHELL were only one or two generations removed from the wild. The following description of *N. quadrivalvis* Pursh is taken from Gray's *Synoptical flora of North America*.

N. QUADRIVALVIS Pursh. A foot high, rather stout, more or less viscid pubescent, low-branching: leaves oblong or the uppermost lanceolate and the lower ovate-lanceolate, acute at both ends, mostly sessile (3–5 in. long); the

[1] Contribution from the Laboratory of Genetics, Bussey Institution of Harvard University. No. 14.

[2] I had the pleasure of describing some of my experiments with *Nicotiana* hybrids to Professor SETCHELL, during his visit to Boston last winter. He said at that time that he had reached conclusions similar to mine in regard to *N. Bigelovii* and *N. quadrivalvis*, although what experiments he has made I am unable to state.

lowest larger and petioled: flowers few; calyx teeth much shorter than the tube, about equalling the 4-celled (or sometimes 3-celled?) capsule: tube of the corolla barely an inch long, the 5-lobed limb an inch and a half or more in diameter; its lobes ovate and obtusish, veiny.

Oregon, and cultivated by the Indians from Oregon to Missouri; their most prized tobacco plant. Perhaps a derivative of the preceding species.[3]

Three sets of seed, purporting to be this species, two from Italy and one from California, were grown. The plants obtained were

FIG. 1.—At left, *Nicotiana quadrivalvis* Pursh; at right, *N. Bigelovii* Watson; young plants.

alike in every detail within the limits of fluctuating variation. One selection has bred true for four generations. They differed from the above description in only one character. The lower leaves could hardly be called petioled, although they tapered almost to a petiole. The plants when grown in a normal fertile soil always had a large number of capsules with four cells. There were individual capsules, however, with three and sometimes even two cells on the same plants. This feature is evidently a physiological variation, for when grown in small pots in the greenhouse

[3] This statement, overlooked by me until the conclusion of the experiments, refers to *N. Bigelovii*.

and partially starved, the percentage of two-celled and three-celled capsules is much increased. The progeny of the starved plants gave only normal plants.

GRAY'S description of *N. Bigelovii* Watson is as follows:

N. BIGELOVII Watson. A foot or two high: leaves oblong-lanceolate, sessile or nearly so; the lower (5–7 in. long) with tapering base; the upper (3 to 4½ in. long) more acuminate, with either acute or some with broader and partly clasping base; inflorescence loosely racemiform, with all the upper flowers bractless: calyx teeth unequal, linear-subulate, about equalling the tube, surpassing the capsule: tube of the corolla 1¼ to 2 in. long, narrow, with a gradually expanded throat; the 5-angulate-lobed limb 12–18 lines in diameter.

FIG. 2.—At left, *Nicotiana quadrivalvis* Pursh; at right, *N. Bigelovii* var. *quadrivalvis;* mature plants.

Seed from Italy and from California gave plants agreeing perfectly with this description. What was not so noticeable in the published descriptions of the two species was the remarkable similarity of living plants of the two species *N. Bigelovii* and *N. quadrivalvis*. The latter differs from the former only in its smaller size and the number of cells in the capsule. Even the viscid odor, which is stronger than in other species of the genus with which I am familiar, is the same in both. It naturally occurred to me that they might both be the same species, a thought simply a little more radical than the one that had already occurred to GRAY.

The species were crossed, therefore, and gave perfectly fertile hybrids intermediate in character, with partial dominance of the

four-celled capsule. Unfortunately the cross between the normal two-celled *N. Bigelovii* and *N. quadrivalvis* has been lost. It is interesting from the standpoint of the transmission of that character, and will be remade.

The similarity of the two plants and the fact that they give a cross that is fertile in the F_1 generation is sufficient evidence to convince me that *N. quadrivalvis* Pursh is really *N. Bigelovii* var. *quadrivalvis*. There is further evidence in the fact that *N. Bigelovii* has produced a *quadrivalvis* variety while under observation.

FIG. 3.—At left, *Nicotiana Bigelovii* var. *quadrivalvis;* at right, *N. quadrivalvis* Pursh; in center, F_1 generation of reciprocal crosses.

Several plants from the different selections of *N. Bigelovii* with a single capsule having three cells were observed. Seeds from these plants were selected with the object of producing a race having three-celled capsules. Selection had absolutely no effect. Among the progeny an occasional three-celled capsule was found, but the percentage could not be increased. In this strain of *N. Bigelovii* there was evidently no ability to transmit the three-celled character. It simply gave an occasional zygotic variation of this kind, just as do many other species of *Nicotiana*.

On the other hand, several other plants, typically *N. Bigelovii* in size, produced several three-celled capsules. It is quite probable that they were all progeny of one plant of the preceding generation. One of these plants was selfed and the resulting seed planted on

rich ground the following year.[4] Each plant among the progeny had numerous three-celled capsules, together with occasional two-celled and four-celled capsules. For two generations the strain has bred true to this condition. The only other abnormality observed is the occurrence of a greater number of flowers with six sepals and six petals than is common in the normal *N. Bigelovii* or the *N. quadrivalvis*. About 1 per cent of the flowers from the normal species have the extra petal and sepal, but on individual plants in

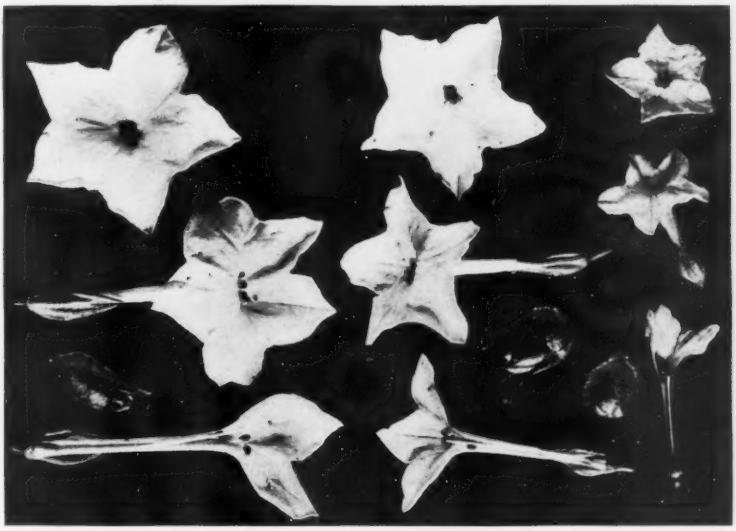

FIG. 4.—At left, *Nicotiana Bigelovii* var. *quadrivalvis;* at right, *N. quadrivalvis* Pursh; in center, F_1 generation of cross.

the aberrant strain of *N. Bigelovii* from 2 to 5 per cent of the flowers vary in this manner.

The aberrant *N. Bigelovii* was crossed reciprocally with *N. quadrivalvis*. The F_1 plants were alike in each case. They were intermediate in stature and in size of flower. The earlier capsules were four-celled; later in the season both three cells and two cells were produced. The F_1 plants were fully as fertile as the parent species. Each plant produced hundreds of well filled capsules.

[4] Seeds are always started in sterilized soil and seedlings set in the open.

One plant each from the cross and its reciprocal were selfed. About 70 plants were grown from each mother plant. No difference was noticed in the two F_2 generations. The entire lot can therefore be considered together. The plants varied in height from one foot to two feet. The flowers were in general intermediate in size, but varied to the extremes that characterize each parent. No plants having only two-celled capsules were found; 71 had a large number of four-celled capsules; 40 had only a few four-celled capsules; while 19 had no four-celled capsules. Every plant had large numbers of three-celled and two-celled capsules, whether or not four-celled capsules were present.

Summary

1. Two elementary species of *N. Bigelovii* Pursh have been found. In one the capsules are two-celled and selection of individuals having an occasional three-celled capsule does not increase the tendency; in the other the tendency to have a greater number of cells than two in the capsule is always transmitted.

2. *N. quadrivalvis* Pursh and normal *N. Bigelovii* Watson are alike in all specific characters except the number of cells in the capsule, and since they give fertile hybrids when crossed it is thought that *N. Bigelovii* gave rise to *N. quadrivalvis*.

3. It is proposed that the section POLIDICLIA in the genus *Nicotiana* be dropped, and *N. quadrivalvis* Pursh be called *N. Bigelovii* var. *quadrivalvis*.

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CURRENT LITERATURE

BOOK REVIEWS

Textbooks of plant physiology

The third edition of GREEN'S *Vegetable physiology*[1] is a newly printed, if not a newly written, book. The first impression to be gained by one who is already familiar with the second edition is that the present volume is a better piece of book manufacture than the older one; especially are the figures brought out much more clearly on the new paper.

A careful comparison of the second and third editions brings out the fact that the essentials of the book remain unchanged in the latter. A good many changes which comprise but a few words are to be noted; some statements are strengthened or weakened or dropped out; some records of discoveries or suggested hypotheses which were originally expressed in the present perfect tense are now thrown into the past; words and phrases are added or removed in the interest of clearness or of elegance; and the paragraphing of the older matter has been here and there improved. A number of new paragraphs have been inserted and some old ones have been supplemented; a few have been totally rewritten. In but a very few cases has the arrangement of the paragraphs been radically altered. A very few figures have been improved by redrawing. While the reviewer is convinced that practically all the changes made are in the direction of the improvement of an already very readable and scholarly treatise, he is distinctly of the opinion that these changes are generally unimportant, and that those who know the second edition practically know also the third.

In general, the chemical considerations seem better framed than the physical ones; the former are often excellent, while the latter are more frequently slighted or seemingly treated in a merely perfunctory way. The time-worn logical fallacy, for example, of supposing that turgidity of cells is produced by hydrostatic pressure (a pressure exerted by *water* to distend a membrane *permeable to water*, through which, indeed, the very water to produce this outward pressure is supposed to have just passed!) is here met with anew.

Even by assuming the position that the *results* of transpiration are the *reasons* for its occurrence, the reviewer is unable to follow the argument of p. 82, wherein it is implied that growth is slow in cacti, etc., because the transpiration rate is low. The proposition appears to be that much water must be

[1] GREEN, J. REYNOLDS, An introduction to vegetable physiology. 3d ed. pp. xviii+470. *figs. 182.* Philadelphia: P. Blakiston's Son & Co. 1911.

transpired in order to bring much saline material into the plant, that large amounts of salts are necessary to rapid and vigorous growth, and hence that with low rate of water loss we must expect slow growth or none at all. After all, in spite of the cuticularization and the relatively small surface exposed by cacti, it is probable that such plants, in their desert habitat, transpire as much per unit of volume as do many very leafy and luxuriantly growing forms of the rainy tropical forest. Furthermore, the growth of the desert cactus occurs in the moister season of the year, exactly at the time when its transpiration is least, or at any rate when it *would be least*, were it not for the slightly cuticularized surfaces of the new growth.

The advance of plant physiology away from the older anthropomorphic interpretation, which seems to characterize the opening of the present century, and the clear indication thus given that we shall ultimately have a purely rational physiology, leads the reviewer to deplore the fact that a text otherwise so perfect and so teachable should be so imbued with the old teleological view of natural phenomena. Of course, it is to be recognized that our science has not, in general, advanced far toward the elimination of this form of superstition; indeed, the author of the volume before us is perhaps with the majority of biologists when he shows that his is a teleological view of plant phenomena. Those teachers who wish to avoid as long as possible the complete reduction of biology to the uncolored and impersonal status of the other physical sciences will find here a textbook which will meet their requirements. For, aside from this imaginative coloring, the book is as nearly suited to its purpose as a book is apt to be. But it should be realized clearly that this is an account of physiological processes from the standpoint of the "benefit" or "advantage" or "purpose" or "aim" of the plant in allowing its various activities to be controlled by physical and chemical conditions. From p. 377 we select: "In considering broadly the result of stimulation we must notice at the outset that it provokes a *purposeful* response. The living substance appears to have a definite aim"; etc. The italics are the author's. Again, on the next page occurs, "Less conspicuously purposeful are those changes in metabolism which are brought about with the supply of food or oxygen, but even here evidence of purpose can be found if sought for."

Our conclusion with reference to the work before us is that while it was for a decade the most satisfactory English elementary presentation of its subject, the advance of the science has made it unsuitable for class work, unless the instructor wishes, indeed, to emphasize the teleological aspect of physiology.

The day of a true science of physiology seems to be at hand, judging from the increased activity in the general phase of this subject witnessed by the last few years. By a true science is meant here a physiology which belongs specifically neither to botany nor to zoology, a science of the phenomena of life, wherever these phenomena may occur. Those who have drawn inspiration and breadth of view from VERWORN'S *Allgemeine Physiologie* will welcome

a volume which has just appeared from the pen of A. PÜTTER,[2] a student of VERWORN'S, associated with him at Bonn. PÜTTER'S book will be especially interesting to physiologists who have entered the science through studies with plants, partly because the author states in his preface that PFEFFER'S *Pflanzenphysiologie* "exerted the most lasting influence upon his scientific development," and still more because of the freedom and general efficiency with which he incorporated numerous facts and principles of plant physiology in his treatise. There has not appeared previously a book of readable size, which is so truly a comparative physiology as is the present volume. About one-fourth of the figures are taken from plant material.

Having announced in his introduction that the study of all life-processes is the field of physiology, and that an understanding of these processes is to be obtained only by *comparison*, the emphasis being laid upon points of similarity in various organisms rather than upon those of difference, PÜTTER proceeds to discuss, with many citations of the more recent literature, the following nine topics, which form the chapter headings of the book before us (i) The substratum of the life processes, (ii) Metabolism, (iii) Nutrition, (iv) Exchange of material, (v) Conditions of life, (vi) Energy transformations, (vii) Responses to stimuli, (viii) Organs of perception, (ix) Nervous system.

In the first chapter, under "The physical constitution of living substance," the author gives a brief but clear presentation of these aspects of colloidal chemistry, an understanding of which is most necessary to physiological thinking. Under "The constituents of organisms," he discusses water and the various groups of chemical compounds that find a place in living beings. The point is well made that water is to be considered as fundamental to all life, and it is shown that, in general, the water content of the active parts of plants and animals may be taken to be about the same.

In the following chapters, of which spatial limitations prevent any consideration here, the author's treatment of the various processes and activities of organisms is always carried out from the standpoint of physics and chemistry, at least the methods of these sciences in attacking a problem are here always evident. Anthropomorphic terms and ways of viewing life-processes are rarely admitted and only with proper logical consideration. The aim is always to arrive as nearly as possible at the underlying principles according to which the different processes go forward, to bring out the cause of each effect and the quantitative relations which exist between these. The book emphasizes in a gratifying and encouraging way the considerable degree to which the simpler mathematical expressions of physical science are already being incorporated in physiological reasoning.

While every reader will find certain points wherein he and the author may disagree, we have found the volume exceptionally logical in its generalizations

[2] PÜTTER, A., Vergleichende Physiologie. pp. viii+721. *figs. 174.* Jena: G. Fischer. 1911.

and exceptionally open-minded in the matter of the many moot questions which so largely make up our present science. What might be considered as errors or inadequacies of treatment are no doubt largely explainable on grounds of lack of space for a full consideration of the questions involved. It is not likely that the book will lead any serious worker far astray.—B. E. LIVINGSTON.

Manual of carboniferous plants

The work, of which Doctor JONGMANS has published the first part under the title cited,[3] is destined to constitute a manual of the carboniferous plants of western Europe. As may be inferred, it is intended for the use of students and paleontologists who have under examination the ordinary impressions and carbonized fragments which constitute over 99 per cent of the material representing the carboniferous floras. The treatment is adapted primarily, therefore, to the identification of such plant fragments. Accordingly the histologist, looking for descriptions or illustrations of the microscopical structure of carboniferous plants, will not find much information of that kind in the work, or at least in its first part. As a matter of fact, there are in the Paleozoic comparatively few plant genera the microscopical anatomy of which is known, because in most formations the geologist very rarely encounters petrified material admitting of histological comparison. Such material, when it is found, is almost invariably limited to restricted areas, as well as very distant stratigraphic horizons. From the stratigraphic standpoint petrified plant fragments, which are apt to lack superficial characters, are of relatively little value.

The paleobotanical matter in the work is arranged to serve the purpose of greatest practical utility. The pteridophytes are grouped in (1) Equisetales, (2) Sphenophyllales, (3) Lycopodiales, and (4) Filicales, to which, as an appendix, is added (5) Cycadofilices or the Pteridospermae. The first volume, embracing 482 pages, ends with the Sphenophyllales. Each group, family, and genus is briefly but lucidly defined, the descriptions and differentiations being often graphic in their simplicity and effectiveness. In most cases where the genus or subgenus includes half a dozen or more species, carefully prepared and most useful keys are introduced to aid in the identification of the fossils. Most of the species are also illustrated to show their diagnostic features, and the pains and good judgment which the author has shown in the choice of his illustrations, a large number of which represent type specimens, contributes materially to the value and importance of the work. All these features combine to make it a reference work for the use of systematic or stratigraphic paleobotanists.

[3] JONGMANS, W. J., Anleitung zur Bestimmung der Karbonpflanzen West Europas mit besonderer Berücksichtigung der in den Niederlanden und den benachbarten Ländern gefundenen oder noch zu Edwartenden Arten. Band I. Thallophytae, Equisetales, Sphenophyllales. 482 pp. *figs. 390.* 's Gravenhage: Mededeelingen van de Rijksopsporing van Delfstoffen. 1911.

In his point of view JONGMANS is generally fairly conservative. His species are for the most part clearly delineated, as shown by the synonomy, though in some cases plants have been included under a single name, which in the judgment of the reviewer, should be maintained separately. An example is *Calamites inornatus* Dawson, here included under *Asterocalamites scrobiculatus*, but really a *Pseudobornia*. On the other hand, there are very many instances of wise and careful reconstruction and correlation. It is assumed that the parts yet to be printed will, like the one in hand, be accompanied by bibliographies and complete indexes, which will aid in making the book the most useful, I may say indispensable, work that has yet been published for the systematic identification of ordinary carboniferous plants.—DAVID WHITE.

Poisonous plants

PROFESSOR PAMMEL has published a *Manual of poisonous plants*[4] whose bulk is a surprise. The reviewer did not imagine that there were so many poisonous plants in the whole world, and the author has restricted himself to "chiefly eastern North America." An explanation is found in the broad interpretation of the subject, for the book includes "all plants that are injurious, although many of these are not known to produce poisons, some even being most useful economic plants and yet injurious to some people."

After the surprise of bulk has subsided, the appalling amount of bibliographical work becomes impressive. At the end of the volume is a bibliography of poisonous plants, a bibliography that must have been traversed more or less completely, and it contains 1237 titles (50 pp.). In addition to this, there is "a catalogue of the poisonous plants of the world" (59 pp.), and also a very complete index (59 pp.).

Part I (150 pp.) includes the presentation of the subject from the standpoint of the poisons, as the titles of the 15 chapters will indicate: Poisons and statistics on poisons; Bacterial poisons; Dermatitis; Forage poisoning, ergotism, and aspergillosis; Poisoning from fungi; Poisoning from other plants—equisetosis, locoism, and lupinosis; Delphinosis, lathyrismus (lathyrism), aconitism, veratrism, Umbelliferae, Conium, Cicuta; Fish and arrow poisons, hydrocyanic poisoning, toxalbumins; Poisoning from opium; Solanaceae and plants that contain saponins; Poisoning from flowers and from honey, mechanical injuries; Classification of poisons, symptoms, and antidotes; Production of poison in plants; Algae in water supplies; Catalogue of the more important poisonous plants of the United States and Canada; Chemistry of alkaloids, glucosides, etc.

Part II (652 pp.) is a descriptive manual, with keys, numerous illustrations, and all the data necessary for determination. The sequence used is that of

[4] PAMMEL, L. H., A manual of poisonous plants; chiefly of eastern North America, with brief notes on economic and medicinal plants, and numerous illustrations. 8vo. pp. xiv+977. *pls. 17. figs. 458.* Cedar Rapids (Ia.): The Torch Press. 1911.

ENGLER and PRANTL'S *Die natürlichen Pflanzenfamilien*, beginning, therefore, with slime molds and ending with thistles; and with each plant there is given the recorded facts as to its injurious effects, and also such medicinal qualities as seem important.

The volume is a great compendium of well-organized information in reference to a subject that has been attracting a good deal of attention recently at national and state agricultural experiment stations in connection with plants injurious to live stock, but of course its scope extends far beyond that special interest. The author is to be congratulated upon the completion of a work that must have involved an unusual amount of patient toil and organizing power.—J. M. C.

Subantarctic New Zealand

The Philosophical Institute of Canterbury, New Zealand, has published in cooperation with the government a most admirable work on the geology, botany, and zoology of the Subantarctic Islands of New Zealand.[5] In the introduction there is given by the editor, Dr. CHILTON, an interesting account of the scientific investigation of these islands; this part contains a number of excellent photographic reproductions of characteristic landscapes. There are six papers dealing with the botany of the islands, one of which is by PETRIE on the grasses (pp. 472–481), one by LAING on the marine algae (pp. 493–527), and one by various collaborators, giving a list of the fungi and bryophytes.

Three botanical papers are of somewhat wider interest and may be noticed briefly. CHEESEMAN gives a somewhat detailed account of the systematic botany (pp. 389–471). This paper includes a historical account of the botanical exploration of the islands, an annotated list of the vascular plants, a tabular view of their distribution in the individual islands and elsewhere in the world, and an interesting concluding part on the affinities of the flora. The flora consists largely of a New Zealand element, representing probably recent immigrations; there is also an interesting Fuegian element, as well as an endemic element. The idea of recent and extensive land connections is not favored.

COCKAYNE gives in his usual satisfactory style an account of the ecological botany of the islands. The leading physiognomic plants are briefly treated, after which the ecological factors are considered, wind being regarded as the most important single factor. Then follows an account of the special ecology of the plants. The body of the paper presents the plant formations, which are more numerous than one might expect to be the case. On the Snares one of the most important formations is the *Olearia Lyallii* scrubby forest. On the Auckland Islands occurs the rata forest, dominated by *Metrosideros lucida*, and known through previous papers by COCKAYNE; this formation tapers off

[5] CHILTON, CHARLES, with various collaborators, The Subantarctic Islands of New Zealand. pp. 848. *1 map. pls. 25.* numerous figs. Wellington, N.Z.: Philosophical Institute of Canterbury. 1910.

into a mountain scrub, consisting chiefly of stunted rata. The Auckland Islands have also extensive meadows and bogs. The paper closes with an account of the important influence played by animals upon the vegetation.

The plant formations of Campbell Island are described by R. M. LAING. This island contains no trees, the tallest vegetation being the *Dracophyllum* scrub; the treelessness is ascribed to the violent westerly gales. Apart from the scrub, Campbell Island has interesting tussock meadows. Some of the geological papers will interest botanists. The zoological papers are of interest chiefly to taxonomic specialists in the groups concerned.—H. C. COWLES.

The geographic botany of Belgium

MASSART's long years of patient study in every part of Belgium have made possible the publication of a splendid treatise on the flora of the country from the standpoint of phytogeography.[6] His previous monograph on the dune vegetation of Belgium is still fresh in the minds of phytogeographers, and the work here noticed is all the more welcome because of the excellent impression made by the earlier volume. This splendid work is dedicated to the memory of ERRERA, and copies were presented to the members of the botanical congress at Brussels. In the introduction the author sets forth his views concerning the methods and purposes of geographic botany, and shows how greatly the methods of ecological geography differ from those of floristic geography. Interesting remarks are made on the relations of "accommodation" to the composition of plant associations.

The first chapter deals with the geology of Belgium, and the second with climate and soil. As is well known, much of the country is of very recent origin, so recent, in fact, that historical records are available as to many points. Under the caption climate there is considered the bearing of various phenological data. The third chapter presents the chief kinds of plant associations that are represented in Belgium. The great density of population of the country for many centuries has greatly modified the natural vegetation cover, yet MASSART has been able to discover and describe a very large number of associations of representative composition, in fact, nearly all that are to be found in western Europe. The chief open associations are found on rocks and on moving dunes, and natural closed associations are represented by heaths, fixed dunes, pans, and bogs. In this part of the volume there are many text figures which illustrate the modification of plants when exposed to diverse conditions. The forests and meadows, as well as the farms and roadsides, are considered under the head of associations modified by human culture. The final chapter considers in detail the various geobotanic districts of Belgium.

[6] MASSART, J., Esquisse de la géographie botanique de la Belgique. Rec. Inst. Bot. Léo Errera, tome supplémentaire VII bis. pp. 332. *figs.* 99. With annex containing 216 simple phototypes, 246 stereoscopic phototypes, 9 maps, and 2 diagrams. Brussels. 1910.

The country is relatively poor in glacial relicts, a few being found in the more elevated limestone areas. There is but one endemic seed plant in the country, *Bromus arduennensis*. This work, like others by the same author, is profusely illustrated by remarkable photographs. It is not too much to say that MASSART is the best of ecological photographers.—H. C. COWLES.

The Lower Cretaceous flora

A volume of the Maryland Geological Survey just issued (1911) contains what is perhaps the most complete systematic account, as yet, of the vascular flora of the Lower Cretaceous. The author, EDWARD W. BERRY, has prepared what is in effect a "manual of botany" for the Lower Cretaceous. To traverse what may be regarded as the rubbish of descriptions from all sorts of "impressions," and to obtain from it something of order, is an attempt that deserves commendation, however much opinion may vary as to the result. We have now before us, in convenient form (pp. 295) and illustrated by 76 plates, this most interesting flora as the paleobotanist, who is at the same time a geologist, looks at it.

In the Maryland deposits of the Lower Cretaceous, BERRY has recognized 145 species in 58 genera, and some appreciation of the vastly greater number of recorded species may be obtained from the long lists of synonyms that appear under many species. The only modern generic names in the list are *Selaginella*, *Equisetum*, *Pinus*, *Populus*, and *Sassafras*, though of course numerous names imply resemblances to modern genera. The pteridophytes include 47 of the species, and 44 of these are thought to belong to the Filicales, the other 3 being one species of *Selaginella* and two species of *Equisetum*. The 3 new genera of Filicales proposed are *Knowltonella* (Matoniaceae?), *Dicksoniopsis*, and *Dryopterites*.

The gymnosperms aggregate 63 species, 33 belonging to Bennettitales and 29 to Coniferales, the remaining one being a *Baiera* (Ginkgoales). Among the Bennettitales, *Ctenopsis* and *Dichotozamites* are proposed as new genera, the latter founded upon forms heretofore referred to *Sequoia*. The angiosperms are represented by 35 species, 3 of which (in 3 genera) are monocotyledons, and among these *Alismaphyllum* is a new genus. The 32 species (14 genera) of dicotyledons include *Nelumbites* as a new genus.

In another part of the volume, BERRY summarizes the Lower Cretaceous floras of the world (53 pp.), listing the recorded species in the various countries.

The volume should be very useful to that increasing number of botanists who are becoming interested in paleobotany, for the scattered and chaotic material of this period has been sifted and brought together in more available form.—J. M. C.

Phylogeny of plants

In 1907 LOTSY began the publication of his lectures on the phylogeny of plants, for the use of students of taxonomy. The first volume[7] contained over

[7] See BOT. GAZ. 43:421. 1907.

800 profusely illustrated pages dealing with thallophytes. The second volume[8] appeared in 1909, and contained over 900 pages dealing with the "Cormophyta Zoidogamia," which include, of course, the "polyciliate" gymnosperms. A third huge volume has now appeared,[9] containing over 1000 pages and representing only the first part on "Cormophyta Siphonogamia." The most impressive fact is the publication, within four years, of nearly 2800 pages, which demanded the traversing of an extensive range of literature for the compilation of facts and illustrations.

The present volume deals with Coniferales, Gnetales, and a part of the Angiosperms. There is no occasion for a detailed review, since the volume is an encyclopedia of our present knowledge in reference to these groups, and of the current speculations in reference to their phylogeny. A casual running through the pages indicates that the author has brought together a remarkably wide range of literature, has included a large number of illustrations from scattered contributions, and has organized his material in such a way as to make it easily accessible. The work as a whole will put the student in touch with the most important morphological contributions of recent years, and in this way will serve as a condensed library.—J. M. C.

MINOR NOTICES

Warming's Handbuch.—A third German edition of WARMING'S *Handbuch*, revised by MÖBIUS, has just appeared.[10] This text is so familiar that only the new features of the present revision need be noted. The changes concern chiefly the thallophytes, which MÖBIUS says "have diverged farthest from the original Danish conception," and especially the algae, in the presentation of which the new system of WILLE has been adopted. There are minor changes in other parts, such changes as may take advantage of a revision rather than demand it.

Perhaps the most interesting feature of the volume is the table representing the evolution of the plant kingdom, the blocks indicating the great groups, having the appropriate pigment colors. All the groups are definitely related, the plant kingdom arising from the flagellates, which give rise directly and independently to seven groups ("Chytridiaceae, Myxomycetes, Schizomycetes, Volvocaceae, Conjugatae, Diatomaceae, Peridineae"), the first four groups mentioned being responsible for all the rest. Anthocerotaceae are

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[8] See *ibid.* **49**:225. 1910.

[9] LOTSY, J. P., Vorträge über botanische Stammesgeschichte, gehalten an der Reichsuniversität zu Leiden. Ein Lehrbuch der Pflanzensystematik. Dritter Band: Cormophyta Siphonogamia. Erster Teil. Imp. 8vo. pp. 1055. *figs. 661.* Jena: Gustav Fischer. 1911. *M* 30.

[10] WARMING, EUG., Handbuch der systematichen Botanik. Deutsche Ausgabe. Dritte Auflage, von Dr. MARTIN MÖBIUS. 8vo. pp. xii+506. *figs. 616.* Berlin: Gebrüder Borntraeger. 1911.

responsible for the vascular plants, giving rise directly and independently to three groups ("Filicineae, Lycopodineae, Equisetineae"), the first of which gives rise to the cycadophytes, while the lycopods produce the conifers and these in turn are responsible for the gnetums and the angiosperms. To the modern student of phylogeny this scheme is more interesting than appealing.—J. M. C.

Arm-chair science.—Sir RAY LANKESTER has brought together in book form a group of papers which he contributed to a London daily paper,[11] and which were addressed, of course, to the general public. It is a good illustration of the attitude of the man of science in England, as contrasted with the attitude of his colleagues in the United States. He wishes the public to know of the achievements of science, and this same spirit makes of the British Association a body of great popular interest. Of course "science from an easy chair" is not exact science, for it talks about subjects in an entertaining and suggestive way rather than about demonstrated facts. But still it is a fair question whether the arousing of interest in this way is not justified by the results.

It is of interest to note a zoologist's selection of botanical topics for such presentation. It is as follows: "A rival of the fabled upas tree" (which turns out to be *Rhus Toxicodendron*), "Poisons and stings of plants and animals," "The simplest living things," "The origin of opium," besides general biological topics that pertain to both animals and plants.—J. M. C.

NOTES FOR STUDENTS

Anatomy of Osmundaceae.—GWYNNE-VAUGHAN[12] has found the course of development of the stele in *Osmunda regalis*, *O. palustris*, and a species of *Todea* to correspond very closely to that already described for *Osmunda cinnamomea*. While the details in different individuals are variable, in general it may be said of all that the juvenile stage is long drawn out, and that at least the first pith formed is "stelar," that is, of intrastelar origin. The nodal pockets or parenchymatous pits in the medullary rays, characteristic of the Osmundaceae, are regarded as rather primitive organs and as having arisen independently of the pith. Perhaps the most interesting observation is the fact that some of the earlier leaf traces in *O. regalis* are mesarch. The main part of the paper is devoted to a discussion of the nature of the pith in the Osmundaceae. The author rightly hesitates to draw any far-reaching phylogenetic deductions from the phenomena observed in the sporeling, but prefers to rest his case, in favor of the view that the osmundaceous pith is stelar, on the fossils described by KIDSTON and GWYNNE-VAUGHAN. These fossils include protostelic ferns, in some of which the central tracheids are shorter than the outer ones, and

[11] LANKESTER, SIR RAY, Science from an easy chair. 8vo. pp. xiii+423. *pls. 2. figs. 82.* New York: Macmillan. 1911. $1.75.

[12] GWYNNE-VAUGHAN, D. T., Some remarks on the anatomy of the Osmundaceae. Ann. Botany **25**:525–536. *pl. 44. figs. 5.* 1911.

siphonostelic ferns in which the medullary rays are narrow or lacking. These feature forms are interpreted as an evolutionary series in which the outstanding is the development of a stelar pith by means of a reduction of the central tracheids and their replacement finally by parenchyma. It would be difficult to prove or disprove this view. That a stelar pith might originate in this way or by an expansion of the stele, as in the roots of many of the higher plants, is unquestioned. But that these fossils represented evolutionary stages which culminated in the conversion of a part of a stelar pith into phloem and endodermis, as in *Osmundites skidegatensis* or *Osmunda cinnamomea*, is unsupported by evidence of any kind.

GWYNNE-VAUGHAN and BOWER accept JEFFREY'S hypothesis as to the extrastelar character of the pith in every other family of ferns, but in dealing with the Osmundaceae they cloud the issue by apparently confusing two problems. From a limited series of imperfect fossils they have tried to discover when and how cortical tissues might have been enclosed by the stele. Failing in this, they conclude that they probably could not have been included at all. But neither are we sure when and how that happened in the other families, and a search through the known fossil representatives would probably end as unsatisfactorily as in the case of the Osmundaceae. Research so far has been successful mainly in verifying the theory that the filicinean pith is extrastelar, and with such forms as *Onoclea*, in which the pith consists partly of epidermal tissues and the atmosphere, there is scarcely any escape from accepting it, just as these botanists have done. It is true that the evidence in *Osmunda* is not as striking as in *Onoclea*, but it is quite as striking as in many other forms with extrastelar piths. There are representatives of the Osmundaceae in which the central pith, peripheral pith, internal endodermis, and internal phloem are texturally like those of the outer cortex, inner cortex, external endodermis, and external phloem, and these respectively are continuous at times through leaf or branch gaps. Moreover, there are abundant instances of what in other groups would readily be conceded vestiges of portions of amphiphloic siphonosteles. Applying the same standards of interpretation of anatomical phenomena to all the Filicales, it seems reasonable to maintain that the kind of evidence that has carried conviction in every case but one must hold in all. The question as to when and how the extrastelar pith originated is quite another matter, and I venture to affirm that observations on such features as the relative position of a tracheid and a parenchyma cell in the xylem of a sporeling, or the shape of medullary rays in an adult, will help little in its solution.—J. H. FAULL.

Biology of lichens.—In his culture studies TOBLER[13] used *Cladonia glauca* Floerke and *C. squamosa* (Scop.) Hoffm. By carefully scraping the branches, clusters of soredia were separated. These were sown on sterile

[13] TOBLER, F., Zur Biologie von Flechten und Flechtenpilzen. II. Die Entwicklung der Cladonia-Soredien. Jahrb. Wiss. Bot. **49**:409–417. *pl. 3. figs. 11.* 1911.

earth in flower pots so thickly as to be visible to the eye. The soil was kept from drying by applying distilled water. Cultures of *C. glauca* showed a green growth over the surface of the soil in six or eight weeks. This growth was examined after four months and proved to be a practically pure culture. There was no evidence at this time of development of thallus layers, the structure being gelatinous-granular. The central more moist portion of the culture was green, portions nearer the margin of the pot yellow-white, and the margin white. Microscopic examination showed that the white margin was composed of the lichen hyphae, while other portions of the culture showed the algae present. The thallus layers began to form in six to nine months, the young thalli arising from granules, each of which often arise from two or more soredia. The lichen hyphae were found to become coherent over small areas, and the algae in turn became more deeply seated in the mass. These young squamules were at first few and widely scattered, but later they were seen in large numbers over the surface of the soil.

TOBLER also made a series of cultures on earthen plates. By keeping the air and soil moist in the plate, the hyphae grew luxuriantly. Then he allowed the cultures to dry out for two months. On moistening again, soredia-like masses appeared at certain points over the surface of the soil. Some of these masses were white and composed wholly of lichen hyphae, while others were pale or darker green. These masses increased in size slowly, but did not differentiate into thallus layers.

Hanging-drop cultures were also tried. In three months the soredial masses had grown considerably, and the lichen hyphae were seen radiating beyond the algae in all directions, though the algae had for a time developed more rapidly than the hyphae. Some of the soredia disintegrated and gave rise to many free spherical algae, which he thinks may have passed through a motile condition. Lichen hyphae were seen growing over these algae, but only occasionally attached to them.

The responses to conditions of moisture and light were studied. It was found that soredia from both species would grow luxuriantly after the branches bearing them had been kept in a dry room at about 10° C. for five months. Both the lichen and the algae retained their vitality and grew when moisture was again applied, but the former better than the latter. After cultures had remained in the dark for two or three months, no remains of the algae could be found, while the lichen hyphae had grown well, probably becoming saprophytic on the algae.

TOBLER'S results correspond well with what has been observed in nature, where soredia-like growths are often observed growing about patches of *Cladonia*. Like his cultures, these show in some places a pure white color due to strong development of lichen hyphae, and in other places a light or darker green color, depending upon the number of algae present. The soredia grow slowly both in nature and in cultures. A considerable amount of moisture is necessary for the development of the soredium as a whole, yet the soredium

can endure drying for about a half year at least. The algae endure large amounts of moisture, perhaps better than the lichen hyphae, but the hyphae endure dryness better than the algae. It would add greatly to the value of the research if the cultures could be kept long enough to ascertain the time and conditions necessary for the development of podetia and apothecia.—BRUCE FINK.

Light in relation to tree growth.—A recent bulletin from the Forestry Service, by ZON and GRAVES,[14] will be welcomed by botanists and foresters as a valuable addition to their literature. The authors first show the influence of light on the life of the tree, then discuss the most noteworthy experiments in measuring this influence. The different kinds of light, namely, direct and diffused, and overhead, side, and reflected, are described. Diffused light is the most important, but some plants need direct as well as diffused light, either during their entire life, or at their time of flowering and leafing. An interesting table is given showing the decrease of both direct and diffuse light with increase of latitude, direct light decreasing most, till at the pole it is zero, whereas diffused light is 20. At the equator direct light is 489 as against 227 for diffused light. The rôle of direct and diffused light in trees and forest development, as well as variation of these light quantities with altitude and latitude, is discussed. The minimum light needed for various trees receives attention, considerable data on this topic being cited from WIESNER'S well-known researches.

The greater part of the Bulletin is devoted to tolerance, the ability of plants to endure shade. The factors affecting tolerance and the methods of determining it are fully discussed. The results of LUBIMENKO and of GRAFE, dealing with the effect of sensitiveness of the chloroplast and of anatomical structure upon tolerance, are briefly stated. There is also a statement of the influence of climate, altitude, soil moisture, soil fertility, and age, vigor, and origin of the trees upon tolerance. Lists of trees are given showing the order of tolerance as determined by various European and American workers. Finally, the methods of determining tolerance are considered under three heads: (1) empirical methods; density of crown, self-pruning, number of branch orders, natural thinning of stand, conditions of reproduction, relative height, and artificial shading; (2) anatomical and physiological methods; structure of leaves and assimilation capacity of leaves; and (3) physical methods; measurement of luminous light intensity and measurement of chemical light intensity. The authors emphasize the general agreement in order of tolerance of various species as determined by the empirical and by other methods. They also point out the weak points in the various methods. One feels that ZEDERBAUER'S luminous light method is underrated; while WIESNER'S photochemical method, with its evident shortcomings, is over-

[14] ZON, RAPHAEL, and GRAVES, HENRY S., Light in relation to tree growth. U.S. Dept. Agric., Forest Service, Bull. 92. pp. 59. 1911.

valued. Both of these methods are defective in that they fail to recognize the importance of non-luminous rays in plant processes, a fact that has been thoroughly established by BROWN and ESCOMBE.—BARRINGTON MOORE.

Plant formations of Caithness.—A report by CRAMPTON[15] on the ecology of some of the northern parts of Scotland relates the development and succession of the various plant associations to the physiography of the region to an extent quite surpassing previous discussions of the vegetation of the British Isles. There is also a dynamic point of view maintained throughout and particularly emphasized in the study of the progressive and retrogressive phases of the moorland formation. The author not only recognizes the stable and successional formations of the topographic cycles, but also the regional successions as exemplified in the remains of tundra, forest, and moorland vegetation found in the peat mosses. This full appreciation of the dynamics of plant formations marks the study as one of first rank, and indicates a decided advance for British ecologists.

The extinct formations recognized are the pine forests, the tundra, and the arctic peat mosses, all related to the advancing and receding ice sheets of the geological period of glaciation, while the existing formations include the alpine and subalpine, the moorland, and, in less prominent development, those of the drainage system and coastal belt. From the exposure and altitude of most of the area studied, associations of sphagnum and other mosses and of the heather are the most abundant types of vegetation. Among the problems discussed, two may be cited as of special interest and as indicating to some extent the scope of the work. The one deals with the relationship of the *Calluna* mat of the alpine plateaux to the destructive winds, resulting in the development of a series of ridges and troughs of vegetation; the other is a part of the ecological relations of the moorland to the drainage system, and demonstrates the present decline of the peat bogs with the advance of river erosion. The reaction of sphagnum growth upon drainage and erosion is also carefully considered, as well as the competition between *Sphagnum* and *Calluna*, the two most conspicuous members of the moorland vegetation.—GEO. D. FULLER.

Fertilization in Taraxacum.—RAUNKIÄR'S castration experiments on several forms of *Taraxacum*, as well as MURBECK and JUEL'S cytological investigations, have proved that parthenogenetic or apogamous development of the embryo prevails in this genus. DAHLSTEDT later published the view that in two or three species of *Taraxacum* grown in a Belgium garden pollination seemed necessary to seed formation. ROSENBERG has described the normal occurrence of the reduction division in the nucleus of the embryo sac mother cell of *Taraxacum*, and HANDEL-MAZZETTI has announced the appearance of

[15] CRAMPTON, C. B., The vegetation of Caithness considered in relation to the geology. pp. 132. Edinburgh: Published under the auspices of the Committee for the survey and study of British vegetation. 1911.

hybrids among the species of the genus. From this statement it is evident that normal fertilization in certain species of *Taraxacum* might be expected.

IKENO[16] has been investigating this situation, and has published recently some of his results. Two species of *Taraxacum* grow in Tokyo, *T. platycarpum* Dahlst. and *T. albidum* Dahlst. During 1908 and 1909, TANAKA, after RAUNKIÄR'S method, made castration experiments with the two species and found that *T. albidum* only formed seeds parthenogenetically. In the spring of 1910, IKENO found growing in a field three different varieties of *T. platycarpum* which might perhaps be elementary species in the DEVRIES' sense. With these forms, he performed the following experiments. When the heads were enveloped with sacs, no seeds were matured; which means that in this case there occurred neither self-fertilization, parthenogenesis, nor effective pollination among the flowers in the same head. A similar experiment was tried with *T. albidum*, and the heads with and without sacs produced seeds. Then he took another variety of *Taraxacum* and put sacs around the heads, which later withered entirely. Then he brushed the surface of the heads of the variety before applying sacs, in order to carry the pollen of one flower to another of the same head, and only 5 out of 80 flowers in a head matured perfect seeds; but when the pollen of another head was applied, the majority of the flowers matured seeds. From these experiments he concludes that in *T. platycarpum* there occur no cases of parthenogenesis, while in the other forms of *Taraxacum* cases of parthenogenesis and normal fertilization both occur.—S. YAMANOUCHI.

Inflorescence and ovules of Gnetum.—Mrs. THODAY (SYKES)[17] has investigated the ovulate strobilus and ovules of *Gnetum africanum*, from material obtained by PEARSON during the Percy Sladen Memorial Expedition in southwest Africa. The vascular situation presents some facts of unusual interest. In the nodes of the ovulate strobilus three concentric rings of bundles occur, the middle one being oriented inversely in relation to the other two, and concentric bundles occurring frequently in the two outer rings. The vascular connections of a single ovulate "flower" in *G. africanum* are said to bear "a remarkably close resemblance to the method of supply to the axillary inflorescence in *Bennettites*." A ring of bundles enters the base of the ovule, and finally breaks into three sets, which traverse the three "coverings" of the ovule, the innermost set traversing the inner integument to and sometimes beyond its separation from the nucellus. A well developed pollen chamber is present in the young ovule, and later the apex of the nucellus hardens and forms a pointed cap.

[16] IKENO, S., Sind alle Arten der Gattung *Taraxacum* parthenogenetisch? Ber. Deutsch. Bot. Gesells. **28**:394–397. 1911.

[17] THODAY (SYKES), MARY G., The female inflorescence and ovules of *Gnetum africanum*, with notes on *Gnetum scandens*. Ann. Botany **25**:1101–1135. *pls. 86, 87. figs. 16.* 1911.

The conclusions are that "the radial structure of the seed, the short free apical portion of the nucellus, the presence of a pollen chamber, the extension of the bundle system into the free portion of the inner integument, the complex structure of the outer integument, are all points of contrast with *Welwitschia*, and probably indicate the more primitive nature of the *Gnetum* ovule." Resemblances to *Bennettites* are also pointed out, and the general impression is left that *Gnetum*, *Welwitschia*, *Bennettites*, and *Lagenostoma*, on the basis of ovule structure, are all from some common ancestral stock.—J. M. C.

Annual ring and medullary rays of Quercus.—GROOM[18] has investigated the evolution of the annual ring and medullary rays of the oak, using numerous and widely distributed species, and has reached the following conclusions. The very distinct annual rings of the deciduous species become less marked in evergreen species, but may be recognized by certain structural features that are enumerated, any one or more of which may be lacking. There is an interesting correspondence between the habit and the arrangement of the large vessels in the annual ring. "Species showing the most striking pore-zone are deciduous; those showing it regularly and distinctly, but not having so marked a disproportion in size between the innermost and outermost vessels, are subevergreen; whilst those species with no trace of a pore-zone are truly evergreen." In addition to these categories, there are transitional forms with corresponding transitions in the pore-zone display.

All species were found to possess uniseriate shallow medullary rays, and some possess also broad, high multiseriate rays; and there are numerous transitional stages between these two kinds of rays. The author was not able to decide which type was primitive, the evidence being contradictory as yet. There are cases, as in seedlings of *Quercus* and *Alnus* (BAILEY and EAMES), in which narrow rays form broad ones; other cases, as in *Fagus* (JOST), in which broad rays divide into smaller ones; and still other cases, as in seedlings of *Fagus* (TABOR), in which both kinds of changes go on simultaneously in the rays of the same annual ring.—J. M. C.

Animal parasites of Nepenthes.—An interesting case of symbiosis, somewhat analogous to the presence of intestinal parasites in animals, has been reported by JENSEN.[19] The pitchers of *Nepenthes* have long been known to be partially filled with a fluid containing enzymes in which dead insects seem to be digested, but only with the observations of the present author has attention been directed to the fact that several species of dipterous larvae appear to develop normally in this fluid. So abundant are they that JENSEN declares that of the hundreds of pitchers he has examined from year to year at Tjibodas,

[18] GROOM, PERCY, The evolution of the annual ring and medullary rays of *Quercus*. Ann. Botany **25**:983–1003. *pls. 74–76*. 1911.

[19] JENSEN, HJALMAR, *Nepenthes*-Tiere. II. Biologische Notizen. Ann. Jard. Bot. Buitenzorg Suppl. 3. pt. 2. 941–946. 1910.

he has failed to find a single one without living tenants. These larvae have been reared and studied by MEIJERE,[20] who describes 7 species, of which 6 are new. They are to be referred to the order Diptera, and belong to three different families.

Not the least remarkable characteristic of these larvae is the power they seem to possess of anti-fermentation, and which appears to retard the action of the enzymes of the fluid filling the pitchers. Experiments upon their influence upon the action of solutions of pepsin and pancreatin furnish evidence of their retarding influence. Closely related larvae, taken from pools in the vicinity, were unable to live in the pitchers; hence the anti-ferment is regarded as an adaptation to such symbiotic existence.—GEO D. FULLER.

Grape mildew.—A number of infection experiments, bringing out some of the relations between the downy mildew of the grape and its host, have been described by MÜLLER-THURGAU.[21] Pot-grown grapevines were brought into a greenhouse, and only the new shoots that developed under glass were used for the experiments. The infected shoots were covered for a time with glass cases, to prevent too rapid evaporation of the drops of water containing the spores used for inoculation. The main results of the experiments are the following: No infection took place on the upper surface of the leaves unless punctures had been made in the epidermis. Infections took place readily on the lower surface if the plants were kept in a moist atmosphere. The very youngest leaves were not readily infected, a fact which the author attributes to causes within the leaf rather than to such outer factors as the dense hairy covering. Leaves a little older are most easily infected and in these the fungus grows a long time and forms spots of considerable size before the infected area dies. On the older leaves the action of the fungus is more severe. The infected spots remain small, usually 3–5 mm. in diameter, but the tissue within these spots is killed immediately. In these small spots large numbers of oospores are found. The difference in behavior of leaves of different ages is attributed to differences in moisture content or to differences in composition. —H. HASSELBRING.

Egg-formation in Cystosira and Sargassum.—NIENBURG[22] reports the result of his investigation on the development of the eggs of *Cystosira* and *Sargassum*. *Cystosira barbata* Ag. was collected at Naples in the spring of 1907, and *Sargassum linifolium* was obtained from Triest in September of the following year. The paper presents briefly the nuclear divisions in the oogonium of *Cystosira* and the development of sporelings of *Sargassum*. The author

[20] MEIJERE, J. C. H. DE, *Nepenthes*-Tiere. I. Systematik. Ann. Jard. Bot. Buitenzorg Suppl. 3. pt. 2. 917–940. 1910.

[21] MÜLLER-THURGAU, H., Infection der Weinrebe durch *Plasmopara viticola*. Centralbl. Bakt. II. **29**:683–695. *fig. 1*. 1911.

[22] NIENBURG, WILHELM, Die Oogonentwicklung bei *Cystosira* and *Sargassum*. Flora **1**:167–180. *pls. 1, 2. figs. 9*. 1910.

followed the nucleus in the oogonium of *Cystosira* from the young resting stage to synapsis, metaphase of the first division, and second and third divisions. The number of chromosomes in the first division he reports to be 18–20. He compares the figures of the first division with those of vegetative divisions, and because of the appearance of a much higher number of chromosomes in the vegetative figures, he infers that 18–20 is the reduced number. Further, upon comparison with the case of *Fucus*, he infers that the oogonium of *Cystosira* and *Sargassum* may represent the *x*-generation. The development of the sporelings of *Sargassum* is discussed in comparison with SIMONS' work on another species of the same genus. The reviewer thinks that it is very desirable to have more detailed accounts of the events occurring in the oogonium of these forms and of the processes connected with the development of a normally fertilized or a parthenogenetic egg.—S. YAMANOUCHI.

Spermatogenesis in liverworts.—WOODBURN,[23] while studying spermatogenesis in *Porella*, traversed the work of IKENO, ESCOYEZ, and SCHAFFNER in *Marchantia polymorpha* and that of BOLLETER in *Fegatella conica* for evidences of centrosomes. In none of the forms studied did he find any evidence of centrosomes. Although occasional granules were found in the cytoplasm, or in the region of the spindle, they did not present the appearance of or behave like centrosomes. He concludes that if a body does sometimes occupy the pole of a spindle it does not imply that it is any more a centrosome than the other bodies scattered through the cytoplasm. He says that the blepharoplast develops *de novo* from a dense granular or spherical mass, kinoplasmic in origin, located usually at the most distant angle of the spermatid. The blepharoplast becomes a cord, growing in close contact with the plasma membrane. He thinks the "cytoplasmatischer Fortsatz" of IKENO is merely a part of the blepharoplast. Nothing whatever corresponding to a "Nebenkörper" was found. He concludes that the sperm at maturity represents the two constant cell elements, nucleus and cytoplasm; that the main body of the cell represents the nucleus; that the blepharoplast and cilia represent specialized cytoplasm; and that the remainder of the cytoplasm is found in the vesicle.—W. J. G. LAND.

Records of Oenothera.—GATES[24] has undertaken to trace the history of species of *Oenothera* in cultivation, particularly the large-flowered forms. This involved a critical examination of the records through three centuries, beginning with TOURNEFORT'S *Institutiones*. The pertinent evidence is recited from the documents in detail, and the conclusion reached that "a form closely resembling *O. Lamarckiana* was the first *Oenothera* introduced into Europe

[23] WOODBURN, W. L., Spermatogenesis in certain Hepaticae. Ann. Botany **25**: 299–313. *pl. 1.* 1911.

[24] GATES, R. R., Early historico-botanical records of the Oenotheras. Proc. Iowa Acad. Sci. **17**:85–124. *pls. 6.* 1910.

from Virginia (about 1614), and therefore that it did not originate in cultivation." Since the writing of the paper, the author has had an opportunity to examine type specimens and early collections in London, and is now inclined to believe that this "first *Oenothera*" was rather the European *O. biennis*, with somewhat large flowers but shorter style. It is of further interest to note in the paper that the author regards *O. Lamarckiana* and all open-pollinated forms as hybrids and not pure races, in the sense that they have undergone crossing in nature as well as in gardens. This means that the important matter to investigate is the relation between this crossing and the phenomena of mutation. At the same time, the author does not believe that there is evidence for regarding *O. Lamarckiana* as an ordinary synthesized hybrid, produced by the crossing of such forms as *O. grandiflora* and *O. biennis*.—J. M. C.

Influence of aspect on vegetation.—From a careful study of the distribution of various plant associations and plant species on the mountain sides of southern Arizona, BLUMER[25] states as a general truth that reversion of aspect takes place with change of altitude. Various species of oak and pine furnish much of the evidence upon which this generalization is based, hence the distribution of *Quercus reticulata* upon the Santa Rita Mountains may be cited as an example. It is first found in shaded situations upon north slopes at 6000 feet, and becomes common as a tall clean coppice form at 6500 feet, spreading to the east and west slopes. At 8000 feet it is practically absent from the north side, is abundant on the east and west, and has begun to appear freely on the south side, where it continues as a chaparral growth to an altitude of 9400 feet. A similar change of aspect is exemplified in the occurrence of various other species. The factor concerned in these changes of aspect is the difference in isolation.

The species studied seem to have occupied all the space they are capable of doing, those with the widest range of variations in form and structure having, by virtue of their plasticity, the widest distribution, but even to such forms no extension of range seems possible while the present topography and climate endure.—GEO. D. FULLER.

Orchid bulbs as fungicides.—Small portions cut from the bulbous parts of certain orchids appear to have a toxic effect upon the mycorhiza of the same plants. In experimental cultures conducted by BERNARD[26] they were very fatal to the hyphae of some species of the fungi, destroying all that came in contact with the fluids diffusing from the bulbous material. Certain other species of fungi isolated from orchid roots proved more resistant, fatal effects being evident only in the presence of larger masses cut from the bulbs. Heated

[25] BLUMER, J. C., Change of aspect with altitude. Plant World **14**:236–248. 1911.

[26] BERNARD, NOEL, Sur la function fungicide des bulbes d'Ophrydées. Ann. Sci. Nat. Bot. IX. **14**:221–234. 1911.

to 55° C. the toxic properties seem to have been destroyed, which together with other data leads to the conclusion that the substance acting as a fungicide is an enzyme. It serves to explain the fact that no endophytic fungi are found in the bulbous portions of various orchids, although they are always present in the roots of the same plants, thus conforming to BERNARD's hypothesis that these orchids are plants which tolerate the mycorhiza, while at the same time they are able to defend themselves against their complete invasion. These investigations were still in progress when they were interrupted by the death of the brilliant scientist who has contributed so largely to the understanding of the symbiosis existing between various endophytic fungi and their hosts.—GEO. D. FULLER.

Vegetation of islands and peninsulas.—From a brief study of the irregular shore line of Lake Tsala Apopka, Florida, and an examination of the literature on the vegetation of the Atlantic coastal plain, HARPER[27] finds that the peninsulas and islands are almost universally characterized by a vegetation of a climax type composed largely of broad-leaved evergreen trees, among which *Magnolia grandiflora* and *Quercus* spp. are conspicuous. This is in striking contrast with the pine forests which occupy the adjacent mainland. Several possible hypotheses in explanation of this phenomenon are examined and rejected, as fire seems to the investigator to afford an adequate key to the situation. Fires would doubtless be of much less frequent occurrence upon islands and peninsulas than upon the more continuous mainland, and this circumstance would permit a more rapid advance toward mesophytism, but it seems possible that differences of soil moisture and evaporation due to the proximity of considerable bodies of water and to the slight elevation of the islands and peninsulas above their surface may have been at least secondary factors in hastening the development of the climax vegetation.—GEO. D. FULLER.

Phylogeny of algae.—BRUNTHALER[28] has discussed the phylogeny of algae, based upon results he obtained from culture experiments and those obtained by ENGELMANN, OLTMANNS, STAHL, PÜTTER, and others. A brief summary of his conclusions is as follows: (1) The chromophyll and chlorophyll of Rhodophyceae, Phaeophyceae, Zygophyceae (including Peridinales, Bacillariales, and Conjugales), are the result of adaptation to light intensity since these forms first appeared. (2) The modern Flagellatae are end structures from the oldest organisms, but the direct relationship of the modern flagellates with these ancient organisms cannot be demonstrated. (3) The Rhodophyceae are to be regarded as phylogenetically the oldest group of algae, and their ancestors have come from the primitive forms of flagellates. (4) The Phaeo-

[27] HARPER, ROLAND M., The relation of climax vegetation to islands and peninsulas. Bull. Torr. Bot. Club **38**:515–525. 1911.

[28] BRUNTHALER, JOSEF, Zur Phylogenie der Algae. Biol. Centralbl. **31**:225–236. 1911.

phyceae are the next younger group of algae, descended partly from Rhodophyceae and partly from flagellate-like organisms. (5) The Zygophyceae are derived from flagellated ancestors, the Peridinales being most nearly related to the modern flagellates. (6) The Chlorophyceae are the youngest of the algae, and have come partly from Rhodophyceae and partly from flagellated ancestors. —S. YAMANOUCHI.

Sporangia and spores of Aneimia.—STEVENS[29] has investigated the development of the sporangia and spores in a species of *Aneimia*. He finds that the two tapetal layers break down at the mother cell stage, freeing the protoplasts and resulting in a tapetal plasmodium, as among the Ophioglossales. It was in connection with work on *Botrychium* (1906) that STEVENS proposed the excellent descriptive phrase "tapetal plasmodium." Perhaps it was a slip that he did not include this earlier paper in the "literature cited," or the still earlier paper of CARDIFF (1905). Upon the separation of the mother cells in *Aneimia* the plasmodium entirely surrounds each one. As each mother cell lies imbedded separately in the plasmodium, no wall is seen, and when the tetrad is formed the mother cell membrane persists about it. At the separation of the spores of a tetrad, the tapetal plasmodium flows between them. The author thinks that the thickness of the exine "is the work of the tapetal plasmodium." It is becoming more and more evident that in structure and behavior the Ophioglossales and Filicales belong together.—J. M. C.

Chromosomes in maize.—KUWADA[30] has studied the nuclear conditions in the pollen mother cells of nine different races of corn: red starch corn, yellow starch corn, amber rice popcorn, black starch corn, golden broach field corn, white flint corn, sugar corn, early light sugar corn, and red sugar corn. The number of gemini in these different races varies from 9 to 12, the sugar corns having generally a larger number than the starch corns. He thinks that the smaller number was reduced from 12, which is the original number for all the races of *Zea Mays*. The size and shape of the gemini in a figure differ, and there is present always a duplication of each of the gemini. In the equatorial plate of the homotypic division some pairs of chromosomes come in contact with each other. He suggests that the production of innumerable races of *Zea Mays* might have a certain relation to the duplication of chromosomes, resulting in the double number derived from the original form, which had probably 6 chromosomes as the reduced number.—S. YAMANOUCHI.

Botryopteris antiqua.—This interesting paleozoic fern, described by KIDSTON in 1908 from inadequate material, has been studied by Miss BENSON[31]

[29] STEVENS, WILLIAM CHASE, On the development of the sporangia and spores of *Aneimia phyllitidis*. Ann. Botany **25**:1059–1068. *pls. 84, 85.* 1911.

[30] KUWADA, Y., Maiosis in the pollen mother cells of *Zea Mays* L. Bot. Mag. Tokyo **25**:164–181. *pl. 6. figs. 4.* 1911.

[31] BENSON, MARGARET, New observations on *Botryopteris antiqua* Kidston. Ann. Botany **25**:1045–1057. *figs. 3. pls. 81–83.* 1911.

from a more abundant collection. The axis was rhizomatous, giving off numerous roots at intervals, and bearing two kinds of leaves, one set of petioles being supplied by a monarch leaf trace, and the other set by a diarch trace. The smaller leaves, supplied by the monarch trace, show at base a sheathing organ which is thought to represent the so-called aphlebia of *Zygopteris;* if so, this is the first record of the structure in *Botryopteris*, and further emphasizes the relationship of the two genera. BERTRAND'S view that the simple stele of *B. antiqua* is due to reduction and not to its primitive character is objected to. As the author says, "this view involves the assumption that the diarch type of petiole is older than the monarch, and the species (*B. antiqua*) is in process of simplification. This result is not easy to harmonize with the fact that later forms of *Botryopteris* petiole are triarch."—J. M. C.

Origin of transfusion tissue.—The so-called transfusion tissue of the leaves of gymnosperms has been recognized for many years as an anatomical feature of the group. WORSDELL (1897) suggested, on the basis of distribution and nature, that it is a modified centripetal xylem. Since the presence of centripetal xylem is an important fact in discussing evolutionary sequences, this view extended the range of recognizable centripetal xylem. Now Miss CARTER[32] has studied the beginnings of this tissue in the cotyledons, using 13 species, representing 9 genera of conifers. The conclusion is "that the first-formed transfusion tracheids appeared in such positions and were of such size as to make it appear improbable that they arose, in these organs at any rate, as an extension of the development of the centripetal wood." The evidence from a comparison with the other elements of the vascular strand suggests that "transfusion tissue" develops from the parenchyma.—J. M. C.

The causes of thorn development.—Since LOTHELIER conducted his researches on the experimental morphology of thorns, it has been generally believed that their development is favored and even caused by abundant light or by atmospheric desiccation. This was supposed to be the case particularly in the gorse, *Ulex europaeus*. ZEIDLER now calls these results in question,[33] for he is able to secure the development of thorns in *Ulex* both in partial darkness and in moist atmosphere. He regards the leafy shoots secured by LOTHELIER in moist air and in darkness merely as juvenile forms, whereas the thorny shoots are regarded as adult forms. It may be remarked that, even if further experiment should confirm the views of ZEIDLER, the real problem is in no wise touched by his experiments. It would still remain to determine why "juvenile shoots" should appear at some times and "adult shoots" at other times.—H. C. COWLES.

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[32] CARTER, M. GERALDINE, A reconsideration of the origin of "transfusion tissue." Ann. Botany **25**:975–982. *figs. 4.* 1911.

[33] ZEIDLER, J., Ueber den Einfluss der Luftfeuchtigkeit und des Lichtes auf die Ausbildung der Dornen von *Ulex europaeus* L. Flora **102**:87–95. 1911.

Swamp vegetation in Japan.—A study of the vegetation of a shallow lake by NAKANO[34] is probably the first ecological investigation to be reported from Japan. The lake represents an ox-bow of the River Tone, and is surrounded by a swamp formation consisting of four concentric zones about the central association of submerged plants, among which various species of *Potamogeton* predominate. The succeeding associations are characterized by *Zizania aquatica*, *Typha angustifolia*, *Phragmites communis*, and *Sagittaria sagittifolia* respectively. The author decides from an analysis of the swamp flora that its closest alliance is with that of China, with 67 per cent of common species; the dominant species, however, are mostly common to North America, although the analysis shows only 27 per cent of common species. The only endemic plant is *Potamogeton lucens* var. *teganumensis*.—GEO. D. FULLER.

Mycorhiza of Solanums.—Seeking for data which could be related to his hypothesis of tuberization being caused by fungal infection, BERNARD[35] had begun the investigation of the various species of *Solanum* for the presence of endophytic fungi when death interrupted his labors. He found, however, that such fungi were present in the rootlets of older plants of *Solanum Dulcamara*, and in the roots of the probable ancestor of the cultivated potato, *S. Maglia*. The latter showed the presence of mycorhiza only when growing under natural conditions, being entirely free from infection as cultivated in botanic gardens and elsewhere in Europe. These results are suggestive of the possible effects of cultivation upon the fungi present in the tubers of the potato, and of their possible influence upon the evolution of tuberization as it now exists in the potato.—GEO. D. FULLER.

Vascular connections of sporocarp of Marsilea.—Ever since the "fertile spike" of Ophioglossaceae has been removed by CHRYSLER and others from the category of an adaxial sporangiophore to that of fused lateral pinnae, the adaxially stalked sporocarp of the Marsileaceae has been a suggestive situation. CHRYSLER studied *Marsilea quadrifolia* and found the vascular connections of the sporocarp stalk to be the same in kind as those of the fertile spike in Ophioglossaceae. Miss ALLISON[36] has now added *M. polycarpa*, in which the petiole bears a varying number of sporocarps, which arise acropetally. She finds that the vascular connections are just as in *M. quadrifolia*, and indicate that the sporocarps are fertile lobes of the leaf. She found also the same condition in *Pteris semipinnata*, a species with pinnules on one side only of the pinna.—J. M. C.

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[34] NAKANO, H., The vegetation of the lakes and swamps in Japan. I. Teganuma. Bot. Mag. Tokyo **25**: 35–51. *figs. 6.* 1911.

[35] BERNARD, NOEL, Les mycorhiza des *Solanums*. Ann. Sci. Nat. Bot. IX. **14**: 235–257. 1911.

[36] ALLISON, HARRIET E., Note on the vascular connections of the sporocarp in *Marsilea polycarpa* Hook. and Grev. New Phytol. **10**: 204–206. *pl. 3.* 1911.

Multiseriate ray of dicotyledons.—THOMPSON[37] has investigated the origin of the multiseriate ray in a number of dicotyledons. He finds that in many families (Ericaceae, Casuarinaceae, Fagaceae, Betulaceae) multiseriate rays are produced "by the breaking up of the ancestral broad compound type," a type which is much broader than either the uniseriate or multiseriate, and consists of an extensive homogeneous mass of parenchyma, such a ray as "gives to the oak wood its characteristic grain." From this origin, as the author infers, the multiseriate ray, the most recent type of ray structure, has spread throughout the wood in the higher dicotyledons. Reversions to the old compound type are to be observed in seedlings, roots, etc., of those plants characterized by multiseriate rays.—J. M. C.

The work of Chodat.—The remarkable range of work that one man may undertake is illustrated by the two most recent fascicles from the Botanical Institute of the University of Geneva. They contain six papers by CHODAT, dealing with the following subjects: an unrecognized *Rhamnus* from the Balearic Islands, which becomes *R. Ludovici Salvatoris* Chod., nom. nov.;[38] the occurrence of green snow on a Swiss glacier, found to be due to a *Raphidium* described as *R. Vireti* Chodat;[39] a description of variegated clusters of grapes, which is a problem in genetics;[40] the first of a series of studies of the Conjugales, dealing with conjugation in *Spirogyra*;[41] a study, from sections, of the stem structure of *Lepidodendron Brownii*;[42] and the description of a new genus of Cyanophyceae (*Ernstiella*).[43]—J. M. C.

Food reserves of trees.—PRESTON and PHILLIPS[44] have investigated the question of the nature and variation of the food reserves of certain American trees, comparing their results with those obtained by European investigators, a summary of whose work they present. Starch appears to be the principal reserve according to most authorities, and in temperate climates a considerable reduction in its amount takes place during the first weeks of winter, but there is no great increase in the content of sugar except at the unfolding of buds

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[37] THOMPSON, W. P., On the origin of the multiseriate ray of the dicotyledons. Ann. Botany **25**: 1005–1014. *pls. 77, 78.* 1911.

[38] CHODAT, R., Un *Rhamnus* méconnu des Baléares. Bull. Soc. Bot. Genève II. **1**: 242, 243. 1909.

[39] ———, Sur la neige verte du glacier d'Argentière. *op. cit.* 294–297. *figs. 4.*

[40] ———, Sur des grappes de raisins panachées. *op. cit.* 359–363. *figs. 3.*

[41] ———, Etudes sur les Conjuguées. 1. Sur la copulation d'un *Spirogyra*. *op. cit.* **2**: 158–167. *figs. 27.* 1910.

[42] ———, L'axe du *Lepidodendron Brownii* (*Lepidostrobus Brownii* Schimpr.). *op. cit.* **3**: 8–13. *figs. 7.* 1911.

[43] ———, *Ernstiella rufa* Chod. un nouveau genre de Cyanophycées coccogènes. *op. cit.* 125, 126.

[44] PRESTON, J. F., and PHILLIPS, F. J., Seasonal variation in the food reserves of trees. Forestry Quarterly **9**: 231–243. 1911.

in the spring. The maximum for carbohydrate reserves for deciduous trees appears to be at the period of leaf-fall, while that for evergreens is at the opening of buds in the spring. There seems to be insufficient evidence that cellulose acts as a winter reserve.—GEO. D. FULLER.

Lens cells in plants.—The position of the investigators who contend that the lens cells occurring in the epidermis of various plants are not essentially organs of light perception will be strengthened by the results of SUMMERS,[45] for in the plants studied phototropic movement occurred only before the development of the lenslike cells. The plant studied is a native of Cape Colony, Africa, where it grows under conditions of intense insolation. The character of the epidermis changes with the age of the leaves, which, at the time the lens cells differentiate, are quite rigid. An incrustation of calcium oxalate is found upon the epidermis, and this, we are assured, functions as a protection when solar illumination becomes too strong for the plant.—GEO. D. FULLER.

Embryo sac and embryo of Garcinia.—A series of investigations on the embryo sac and embryo of angiosperms, by the late Dr. TREUB, has begun to appear,[46] the first paper dealing with two species of *Garcinia* (Guttiferae), *G. Kydia*, and *G. Treubii*. The details of embryo sac formation are described and illustrated, the variations being of minor importance and all referable to categories recorded among angiosperms. The most noteworthy statement is that in reference to the evidence for parthenogensis, which may be said to be suspected rather than proved. The paper adds another angiospermous genus to those that have been investigated, and still further emphasizes the remarkable uniformity of this great group in its essential morphology.—J. M. C.

Nuclear extrusion among Fucaceae.—GARDNER[47] has experimented on the nuclear extrusion of six different forms of Fucaceae: *Fucus evanescens* f. *typicus* Kjellm., *Hesperophycus Harveyanus* Setchell and Gardner, *Pelvetiopsis limita* Gardner f. *typica* and f. *lata*, *Pelvetia fastigiata* Décne, and *Cystosira Osmundacea* Ag. Many irregularities were noted; for example, in the case of *Hesperophycus* the contents of the oogonium finally divided into two eggs, one of which included a single nucleus and the other seven nuclei; the fate of the eggs after escape from the oogonium was not followed. In the case of *Pelvetia*, the six extra nuclei are cast out between the eggs instead of on the surface.—S. YAMANOUCHI.

[45] SUMMERS, F., On the occurrence of lens cells in the epidermis of *Mesembryanthemum pseudotruncatellum*. Ann. Botany **25**:1137–1145. 1911.

[46] TREUB, M., Le sac embryonnaire et l'embryon dans les angiospermes. I. *Garcinia Kydia* Roxb., *Garcinia Treubii* Pierre. Ann. Jard. Bot. Buitenzorg **24**:1–17. *pls. 1–5*. 1911.

[47] GARDNER, NATHANIEL LYON, Variations in nuclear extrusion among Fucaceae. Univ. Calif. Publ. Bot. **4**:121–136. *pls. 16, 17*. 1910.

Silver-leaf disease.—BROOKS[48] has investigated, through inoculation experiments, the silver-leaf disease of fruit trees and other plants, which is said to be more serious in England each year. As the name implies, the foliage of the host becomes silvery in appearance, in striking contrast with the dark green of healthy leaves. *Stereum purpureum* was reputed to be the causal organism, and inoculations of branches of plum trees with its sporophores resulted in silvering. The mycelium was also grown from spores in pure cultures and inoculations with it caused silvering. The conclusion seems safe that this parasite is the active agent in producing the disease in England.—J. M. C.

Lodgepole pine forests.—From a study of the forests of Boulder Park, Colo., MISS BRUDERLIN[49] concludes that the lodgepole pine represents the climax forest formation on the moderate slopes, although none of the trees is over 150 years old and forest fires have frequently occurred in the past. The close relationship found existing between fires and the occurrence of this species seems to agree with the conclusions of CLEMENTS presented in a paper recently reviewed in this journal.[50] The presence of Engelmann spruce, especially in more moist situations, suggests that were the fires prevented the lodgepole pine would be succeeded by more mesophytic conifers.—GEO. D. FULLER.

Michigan fungi.—KAUFFMAN[51] has shown what can be done by some field study of fungi during a single season, and the season of 1910 in Michigan was far from favorable. There were discovered 15 species of Ascomycetes and 77 species of Basidiomycetes hitherto unreported from the state. He has also stimulated the interest in observing fungi by the publication of outline keys to the common genera of these fungi, for the ability to recognize a fungus helps to keep the interest alive. These keys, extending through 27 pages, form the bulk of the contribution, and should meet the immediate needs of those who do not have access to the larger publications.—J. M. C.

Ophioglossum and Pinus.—Miss STOPES,[52] in her examination of cretaceous plants, has discovered that the impressions known as *Ophioglossum granulatum* do not represent that genus, and that the American specimens are staminate strobili of *Pinus*, the so-called "granules" being winged pollen grains. Accordingly the author gives the new name *Pinus granulata*, which may not be

[48] BROOKS, F. T., "Silver-leaf" disease. Jour. Agric. Sci. **4**:133–144. 1911.

[49] BRUDERLIN, KATHERINE, A study of the lodgepole pine forests of Boulder Park (Tolland, Colo.). Univ. Colorado Studies **8**: 265–275. 1911.

[50] BOT. GAZ. **51**: 234. 1911.

[51] KAUFFMAN, C. H., Unreported Michigan fungi for 1910, with outline keys of the common genera of Basidiomycetes and Ascomycetes. Report Mich. Acad. Sci. 215–249. 1911.

[52] STOPES, MARIE C., On the true nature of the cretaceous plant *Ophioglossum granulatum* Heer. Ann. Botany **25**:903–907. *figs. 2.* 1911.

the same species as the Greenland specimens called *Ophioglossum granulatum*. This is another illustration of the great caution necessary in using the determinations of impressions or casts as the basis of conclusions in reference to the history of a group.—J. M. C.

Classification of plants.—Professor BESSEY[53] has issued a second edition of his *Outlines of plant phyla*, the first having been noted in BOT. GAZ. **51**:317. 1911, where it was stated that plants were grouped into 14 coordinate phyla, and their names were given. The present edition contains an interesting census, the enumeration of species, in terms of the four conventional groups, being as follows: thallophytes 79,450 (64,000 of which are fungi); bryophytes 16,000; pteridophytes 4524; spermatophytes 133,040 (only 540 of which are gymnosperms). The total is 233,614 species, distributed among 648 families.—J. M. C.

Vestigial axillary strands of Trichomanes.—It has been known for some time that vestigial axillary strands occur among the Hymenophyllaceae, in addition to the general occurrence of axillary branches. Miss CHAMBERS[54] has examined material of *Trichomanes javanicum* from the Fiji Islands and finds the axillary vestige ending in a conical mass of parenchyma, which suggests the last vestige of an axillary bud. The important fact is that comparable situations in *Helminthostachys* and the Botryopterideae suggest that Botryopterideae, Ophioglossaceae, and Hymenophyllaceae "are in one circle of affinity."—J. M. C.

Discomycetes of Iowa.—SEAVER[55] has brought together in very attractive form the available information in reference to the discomycetous flora of Iowa. It is intended mainly as a guide to local students, and therefore is in manual form, with keys and full descriptions. There are presented 126 species and 56 genera. This average of approximately two species to a genus, 23 of the genera being represented by a single species and the largest one by only 11, indicates that the generic boundaries in the group are rather closely drawn about the species.—J. M. C.

Seeds of Bennettitales.—WIELAND[56] has sectioned an unusually well preserved specimen of *Cycadeoidea* obtained recently from the Black Hills region (near Hermosa), and makes it the occasion for bringing the seed

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[53] BESSEY, CHARLES E., Outlines of plant phyla. 2d ed. pp. 20. Private publication. 1911.

[54] CHAMBERS, HELEN S., The vestigial axillary strands of *Trichomanes javanicum* Bl. Ann. Botany **25**:1037–1043. *figs. 4.* 1911.

[55] SEAVER, FRED J., Iowa Discomycetes. Bull. Lab. Hist. Univ. Iowa **62**:41–131. *pls. 16.* 1911.

[56] WIELAND, G. R., A study of some American fossil cycads. V. Further notes on seed structures. Amer. Jour. Sci. IV. **32**:133–155. *figs. 9.* 1911.

structures of the group into one general survey, and especially the layers of the testa. He reiterates the belief that in the structures referred to *Cycadeoidea* most resembles *Lagenostoma*, and of course it is to be included, on account of its generally ancient features, in the general category of seeds of paleozoic type.—J. M. C.

Flora of Kansas.—Mr. and Mrs. SMYTH have begun the publication of a catalogue of the flora of Kansas,[57] the first part issued containing the mosses and ferns. The large groups are described both taxonomically and morphologically, and the families, genera, and species listed, the habitats and stations also being indicated. The classification is unconventional. It is interesting to note that the display of these groups in Kansas, on the basis of the number of species, is as follows: liverworts 25, mosses 107, pteridophytes 33.—J. M. C.

Mitosis in cereals.—NAKAO[58] presents the results of his study of mitosis in the pollen mother cells of four cereals: *Triticum vulgare*, *Hordeum distichon*, *Secale cereale*, and the hybrid between *T. vulgare* and *S. cereale*. The number of chromosomes is 8 in wheat and rye, and 7 in barley. The appearance of abnormal features in the development of the pollen mother cell was a common tendency, as well as a tendency to degenerate at various stages.—S. YAMANOUCHI.

Calcareous and siliceous vegetation.—BOUGET[59] concludes from a study of calcareous and siliceous floras in the Pyrenees that the plants of calcareous soil are more responsive to seasonal differences than are those of siliceous soil. Calcareous soils also are richer in species than are siliceous soils, and they show at a given altitude a greater mixture of plants whose chief distributional areas are higher and lower.—H. C. COWLES.

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[57] SMYTH, BERNARD B., and LUMINA C. RIDDLE, Catalogue of the flora of Kansas. Part I. Mosses and ferns. Trans. Kan. Acad. Sci. **23**:273–295. 1911. Also issued with index and separate pagination.

[58] NAKAO, M., Cytological studies on the nuclear division of the pollen mother cells of some cereals and their hybrids. Jour. Coll. Agric. Sapporo (Japan) **4**:173–190. *pls. 10–13*. 1911.

[59] BOUGET, J., Note sur la végétation de la bande septentrionale des terrains secondaires dans les Pyrénées. Rev. Gén. Bot. **22**:213–221. 1910.

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